THE FUTURE ROLE AND MISSION OF THE NATIONAL BUREAU OF STANDARDS

WITHDRAWN

HEARINGS

BEFORE THE

SUBCOMMITTEE ON
SCIENCE, RESEARCH AND TECHNOLOGY

OF THE

COMMITTEE ON
SCIENCE AND TECHNOLOGY
HOUSE OF REPRESENTATIVES

NINETY-NINTH CONGRESS

FIRST SESSION

FEB 12 1986

DAILY DEPOSITORY

OCTOBER 1, 2, 1985

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*Ranking Republican Member.
**Serving on Committee on the Budget for 99th Congress.

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THE FUTURE ROLE AND MISSION OF THE NATIONAL BUREAU OF STANDARDS

TUESDAY, OCTOBER 1, 1985

House of Representatives,
Committee on Science and Technology,
Subcommittee on Science, Research and Technology,
Washington, DC.

The subcommittee met, pursuant to notice, at 9:45 a.m., in room 2318, Rayburn House Office Building, Hon. Doug Walgren (chairman of the subcommittee) presiding.

Mr. Walgren. Welcome to our hearing this morning. I apologize for being delayed myself.

Today we begin 2 days of hearings on The Future Role and Mission of the National Bureau of Standards. The Bureau, as most of you know, is this country's oldest national laboratory. It was established by Congress in 1901 to help ensure the compatibility of measurement standards needed by industry, consumers, the scientific community, and obviously a modern society in general. This basic mission of the NBS has increased in importance over the years as technology has grown increasingly complex.

The Bureau is the major generator of basic measurement standards that are vital to new product development, quality assurance, and the maintenance of equity in all kinds of trade relations. The Bureau both maintains the current standards to which American industry calibrates its equipment and also conducts the research which will provide the scientific basis for measurements that will need to be made in the future. These missions take on a special significance now that the United States' trade status has deteriorated so completely in these last number of years.

The Bureau also provides technical support to many other Government agencies as they work to fulfill their respective missions. Since 1965, the Congress has passed about 20 laws giving the Bureau specific assignments, without any significant increase in the Bureau's funding or in the anticipated manpower that the Bureau is able to bring to bear.

In fact, the number of Bureau of Standards personnel has decreased over these years, since 1965, from 3,800 employees to 2,900. Moreover, the 1986 budget proposal proposed an additional 2 percent reduction in the number of GS-11 through GS-15 employees at the Bureau of Standards during each of the next 5 years.

Since these grade levels include the entry levels for Ph.D. scientists, this proposal would certainly have a negative effect on the Bureau's ability to attract high quality scientific personnel which are obviously required to do this kind of work in the proper fashion. No agency bled slowly and continually over two decades, while receiving new responsibilities each year, can maintain the high standards that it set out with. At NBS, as elsewhere, we get a high quality and yet there's obviously a price that must be paid.

Clearly, a review of the Bureau of Standards' mission is now sorely needed. We feel that it is time to look at what we should be doing to enable the Bureau to continue its role of scientific and engineering excellence in this country to exist and to continue to prosper. Also its leadership in the development of standards for society is certainly critical in the future as well as in the past. And we want to understand what is necessary to make that happen.

Given the proper resources, certainly the National Bureau of Standards can make a substantial contribution to this country's efforts to increase productivity and to achieve a higher level of industrial innovation. And yet, we have to understand that it cannot be all things to all people.

We plan to ask witnesses for their views on the Bureau's priorities and on the Bureau's current ability to attain the role that has been staked out for it in the past, as well as for their comments and recommendations on any policy or programming or budgetary changes which should be made to enable NBS to continue to contribute to the health and the strength of the country's future.

With that, let me recognize the ranking minority member on the subcommittee, Congressman Boehlert, for any comment he may wish to make.

Mr. BOEHLERT. Thank you very much, Mr. Chairman. My appreciation of the outstanding work of the Bureau, and my respect for the personnel that are doing that important work remains at a very high level. I have a more detailed opening statement, Mr. Chairman, and I ask unanimous consent that it appear in the record at this point. And let's get right on with the hearing.

Mr. WALGREN. Without objection.

[The prepared opening statement of Mr. Boehlert follows:]

OPENING STATEMENT FOR

Hon. Sherwood L. Boehlert
Ranking Republican Member
Subcommittee on Science, Research and Technology
October 1, 1985

Mr. Chairman, ladies and gentlemen, I am pleased to join the chairman of the SRT Subcommittee, Mr. Walgren, in sponsoring these hearings. The National Bureau of Standards is key to our leadership in the global technological race. The Bureau has a long history of excellent basic research and support of American industry, and to falter in its support would have drastic and far-reaching implications.

I would like to read, if I may, a letter from Nobel Laureate physicist Dr. Arthur Schawlow from Stanford, which was submitted for the record for these hearings and very eloquently summarizes the place of the Bureau:

(read letter attached)

I look forward to the testimony from our distinquished witnesses this morning and thank you again, Mr. Chairman.

STANFORD UNIVERSITY, STANFORD, CALIFORNIA 94305

ARTHUR L. SCHAWLOW
J. G. JACKSON-C. J. WOOD
PROFESSOR OF PHYSICS
(415) 497-4356

September 24, 1985

Science, Research and Technology Subcommittee
U. S. House of Representatives
Room 2319 Rayburn House Office Building
Washington, DC 20515

Dear Sirs:

In response to Chairman Walgren's letter of September 5, I am enclosing some comments on the National Bureau of Standards.

I hope that they will be of some use in connection with the forthcoming hearings.

Yours sincerely,

Arthur L. Schawlow

Comments for the record on **NATIONAL BUREAU OF STANDARDS**

The National Bureau of Standards operates a group of laboratories which have a magnificent record of contributions to the frontiers of science and technology, to the nation's economic welfare and to its military security. Its tabulations of data have been important for many projects. In my own experience, the Bureau's tabulations of atomic energy levels were essential for us to show that lasers were possible.

Even if one were to construe the mission of the National Bureau of Standards in the narrowest sense as the keeper of precision standards and measurement methods for technology, the Bureau could not carry out that mission well without a vigorous program of basic, exploratory research.

In such fundamental research, the scientists of the Bureau have made many great discoveries, which led to major advances in scientific understanding and technology. But they are not the major reason for supporting basic research at the Bureau. Even apart from the specific results of their investigations, the country must have some people who understand the latest scientific advances throughout the world, and are able to apply them to the needs of measurement and technology. To stay in the forefront, they must be active participants in advancing the frontier, so that they have the respect of other leading workers around the world. Sitting in a library and reading reports is not nearly good enough, for printed reports always lag behind the developments and are condensed for presentation.

Indeed, many of the Bureau's researchers are esteemed colleagues, widely recognized in the scientific community, and there is a vigorous interchange between them and their university counterparts. The Bureau's precision measurement grants have played an important role in stimulating outstanding young academic scientists to contribute to the science and techniques of precision measurement.

Clearly, with its combination of outstanding frontier research, development, measurement and tabulation, the National Bureau of Standards is a vital national resource. It should certainly be supported and funded at a level that will keep it able to remain at the forefront of its fields. Anything less is not good enough for this country's needs.

Arthur L. Schawlow
Department of Physics
Stanford University
Stanford, CA 94305

Mr. WALGREN. Are there other members who would like to make opening comments at this point? If not, then let me introduce our first witness for the day, Dr. John McTague, who is the Deputy Director of the Office of Science and Technology Policy in the White House. Welcome to the committee, Dr. McTague. We appreciate your coming and have enjoyed your contributions in the past. We particularly appreciate your being a resource to the committee in this kind of an exploration.

As all the witnesses should know, the written text of testimony will be made part of the record, and you may feel free to summarize, outline, or emphasize your statement in whatever way you feel best communicates what you think ought to be said at this point in the record.

So, Dr. McTague, welcome to the committee.

Dr. MCTAGUE. Thank you, Mr. Walgren.

STATEMENT OF DR. JOHN P. McTAGUE, DEPUTY DIRECTOR, OFFICE OF SCIENCE AND TECHNOLOGY POLICY, THE WHITE HOUSE

Dr. MCTAGUE. America's science base is not a luxury; neither are the institutions which house and foster it. As you in the Congress and we in the White House struggle to tame the unwieldy deficit and maintain this country's economic strength, our thinking must be guided by the principle that science fuels technology and technology generates industrial growth and productivity.

Technology leads to high quality, innovatively manufactured products, creates jobs, and contributes positively to our balance of trade. Together, science and technology form the cornerstone of America's international industrial competitiveness and her national security.

It won't startle anyone here when I say that science and technology are of paramount importance to every aspect of our country's well-being; health, economy, defense, international standing. The statement bears repeating, however, because the extent of that importance is ever more relevant and constantly increasing.

Our mutual challenge demands that we apply an unprecedented degree of creativity to addressing the Federal research and development infrastructure. In particular, we must seek ways to utilize more effectively those resources already in place. Hence, the value of your examination of the National Bureau of Standards—an existing model of the more interdisciplinary, cooperative approach to research and development—which I view as essential to America's technological preeminence.

In parallel trends, the relationship of science to technological advances is becoming closer, while the length of time from scientific discovery to technological applications is shrinking. The National Bureau of Standards occupies a position central to this science to technology to application progression because, unique among Government research facilities, it embraces all those elements in relation to the commercial environment.

Its so-called guest workers, the majority of whom come from universities, bring infusions of fresh insight and experience from the frontiers of basic research. Industry, with whom the Bureau enjoys an exemplary relationship of the sort I expect to see more of in the future, sends its senior scientists to work together with Bureau staff on topics of mutual interest under the auspices of the rapidly expanding industrial associates program.

In addition, industry voluntarily provides assistance in kind with donations of computers and other highly sophisticated equipment—approximately $40 million worth in fiscal year 1985—which Government budgets otherwise might not afford.

Conversely, NBS opens its facilities, many unique of their kind in the United States, for reimbursable proprietary research by industry. The number of such arrangements will increase markedly with the opening of the proposed cold neutron facility.

What we see at the National Bureau of Standards is a quality control maintained by both industry and university voting with their feet.

Foreign competition in the technology intensive industries poses a more serious economic threat to our country's position in the international marketplace than ever before in our history. Over the past 5 years, both Government and industry have responded to this alarming situation by increasing their commitments to research and development. Appropriately we're going with our strength.

According to the President's Commission on Industrial Competitiveness, America's only two significant competitive advantages are her scientific and technical knowledge base, and her talent. Both are strong and show signs of remaining so. To achieve the optimum benefit from these advantages, and to get the maximum return on the Federal investment in R&D, we must take steps to enhance the communication among the performers of R&D; universities, industries, and Federal laboratories.

It is in the best interest of the Nation that we pay special attention to those areas of research important to industrial competitiveness, and invest in the kinds of frontier research that will yield productive new technologies.

The National Bureau of Standards already is a catalyst for, but not the dictator of, the conversion of science and technology to commercial products. In the future it anticipates a shift in focus to the support of manufacturing and processing technologies, clearly areas of fast-paced change where constant refinements will be crucial to sustained industrial competitiveness.

If I had to pick a single area most crucial to our national competitive position where NBS has a central role, it would be in the automation of manufacturing processes.

According to its legislative mandate, the mission of the National Bureau of Standards is to support industry and commerce in this country by providing measurement and standards services. As America depends more and more on the success of industry and commerce for economic and international security, the Bureau is bound to be called on to play a larger role. Fortunately, it has an exceptionally strong record of excellence to build on.

The future will demand of it, as of us all, a new level of creativity and a greater capacity for innovation. There will be changes. At the Bureau, these will undoubtedly involve finding new ways to disseminate its services, exploring the possibilities inherent in computers, data bases, and electronic mail. With the trend toward more encouragement of new entrepreneurs by State and local entities, NBS can expect some new clientele; the State governments which are nurturing entrepreneurial new businesses.

Finally, the Bureau's continued effectiveness will require keeping a constant vigilance over potential new technologies, relying on its own strong basic science capability to anticipate the need for unique facilities to meet it.

Flexibility of funding is a prerequisite to NBS fulfilling its role of providing a base for future technologies.

More extensive interaction with industry, including shared funding arrangements, is a highlight of the Bureau's present and future configuration. I mentioned earlier that NBS benefits already from various manifestations of industrial cooperation, as do its industrial partners. Cooperation between Government, university, and industrial research and development performers, and better interagency coordination of Federal R&D activities, are utterly essential to America's retaining and enhancing her accustomed position of world economic and technological leadership. It is precisely because of its strong generic science and technology base that the Bureau is able to strengthen our industrial posture.

The science and technology community in general must present a united front. It must be just that, a community in the face of competition. We can learn a great deal from the National Bureau of Standards, where sectoral strengths enhance rather than impede multidisciplinary progress.

The cornerstones of present and future NBS strengths are interdisciplinary approaches to problem solving, broad cooperation with universities and industry, the flexibility to respond to changing challenges, and a strong base in fundamental science.

Thank you.

[The prepared statement of Dr. McTague follows:]

Proposed Testimony of Dr. John P. McTague
Deputy Director, Office of Science and Technology Policy
Executive Office of the President

Before the United States House of Representatives
Committee on Sciene and Technology
Subcommittee on Science, Research and Technology

Hearings on the Future Role and Mission of the
National Bureau of Standards

October 1, 1985

Mr. Walgren and members of the Subcommittee:

America's science base is not a luxury; neither are the institutions which house and foster it. As you in the Congress and we in the White House struggle to tame the unwieldy deficit and maintain the country's economic strength, our thinking must be guided by the principle that science fuels technology and technology generates industrial growth and productivity. Technology leads to high quality, innovatively manufactured products, creates jobs, and contributes positively to our balance of trade. Together, science and technology form the cornerstone of America's international industrial competitiveness, and her national security.

I won't startle anyone here when I say that science and technology are of paramount importance to every aspect of our country's well-being: health, economy, defense, international standing. The statement

BEARS REPEATING, HOWEVER, BECAUSE THE EXTENT OF THAT IMPORTANCE IS EVER MORE RELEVANT AND CONSTANTLY INCREASING.

OUR MUTUAL CHALLENGE DEMANDS THAT WE APPLY AN UNPRECEDENTED DEGREE OF CREATIVITY TO ADDRESSING THE FEDERAL RESEARCH AND DEVELOPMENT INFRASTRUCTURE. IN PARTICULAR, WE MUST SEEK WAYS TO UTILIZE MORE EFFECTIVELY THOSE RESOURCES ALREADY IN PLACE. HENCE THE VALUE OF YOUR EXAMINATION OF THE NATIONAL BUREAU OF STANDARDS--AN EXISTING MODEL OF THE MORE INTERDISCIPLINARY, COOPERATIVE APPROACH TO RESEARCH AND DEVELOPMENT WHICH I VIEW AS ESSENTIAL TO AMERICA'S TECHNOLOGICAL PREEMINENCE.

IN PARALLEL TRENDS, THE RELATIONSHIP OF SCIENCE TO TECHNOLOGICAL ADVANCES IS BECOMING CLOSER, WHILE THE LENGTH OF TIME FROM SCIENTIFIC DISCOVERY TO TECHNOLOGICAL APPLICATION IS SHRINKING. THE NATIONAL BUREAU OF STANDARDS OCCUPIES A POSITION CENTRAL TO THIS SCIENCE-TO-TECHNOLOGY-TO-APPLICATION PROGRESSION BECAUSE, UNIQUE AMONG GOVERNMENT RESEARCH FACILITIES, IT EMBRACES ALL THESE ELEMENTS IN RELATION TO THE COMMERCIAL ENVIRONMENT. ITS SO-CALLED GUEST WORKERS, THE MAJORITY OF WHOM COME FROM UNIVERSITIES, BRING INFUSIONS OF FRESH INSIGHT AND EXPERIENCE FROM THE FRONTIERS OF BASIC RESEARCH. INDUSTRY, WITH WHOM THE BUREAU ENJOYS AN exemplary relationship of the sort I expect to see more of in the future, sends its senior scientists to work together with Bureau staff on topics of mutual interest under the auspices of the rapidly-expanding Industrial Associates Program. In addition, industry voluntarily provides assistance in kind, with donations of computers and other highly sophisticated equipment--approximately 40 million dollars worth in fiscal year 1985--which government budgets otherwise might not afford. Conversely, NBS opens its facilities, many unique of their kind in the United States, for reimbursable proprietary research by industry. The number of such arrangements will increase markedly with the opening of the cold neutron facility.

Foreign competition in the technology-intensive industries poses a more serious economic threat to our country's position in the international marketplace than ever before in our history. Over the past five years, both government and industry have responded to this alarming situation by increasing their commitments to research and development. Appropriately, we're going with our strength. According to the President's Commission on Industrial Competitiveness, America's only two significant competitive advantages are her scientific and technical knowledge base, and her talent. Both are strong, and show signs of remaining so. To achieve the optimum benefit from these advantages--and to get the maximum return on the federal investment in R&D--we must take steps to enhance the communication among the performers of R&D: universities, industries, and federal laboratories. It is in the best interest of the nation that we pay special attention to those areas of research important to industrial competitiveness and invest in the kinds of frontier research that will yield productive new technologies.

The National Bureau of Standards already is a catalyst for, but not the dictation of, the conversion of science and technology to commercial products. In the future, it anticipates a shift in focus to the support of manufacturing and processing technologies--clearly areas of fast-paced change where constant refinements will be crucial to sustained industrial competitiveness.

Any future considerations should take into account the increasingly interdisciplinary nature of technology. The biotechnology revolution is a good example of this; a case in which the sheer speed of development has

FORCED A BLURRING OF THE DISTINCTION BETWEEN THE LIFE SCIENCES, THE PHYSICAL SCIENCES, AND ENGINEERING IN RESPONSE TO THE DEMANDS OF THE TECHNOLOGY. MANY FEDERAL AGENCIES ACKNOWLEDGE ALREADY THE TREND TOWARD INTER-DISCIPLINARITY AND ARE LAUNCHING PROGRAMS TO ADDRESS TO IT. WE IN THE WHITE HOUSE SCIENCE OFFICE ENVISION BIOTECHNOLOGY AS POTENTIALLY THE GREATEST GROWTH INDUSTRY--SPRINGING FROM SCIENCE--IN THE NEXT CENTURY, AND ARE ANXIOUS THAT ITS BASE BE VIGOROUSLY PURSUED BY THE FEDERAL GOVERNMENT. I AM PLEASED TO LEARN, THEREFORE, THAT THE NBS PLANS TO WORK ON THE STANDARDS SO ESSENTIAL TO OUR COMPETITIVE POSITION IN PROCESSING TECHNOLOGIES FOR CHEMICALS AND BIOCHEMICALS. I HEARTILY ENDORSE THE BUREAU'S INTENT TO PROVIDE THE BASIS TO ACHIEVE GREATER EFFICIENCY OF PRODUCTION, ENHANCED PRODUCT SPECIFICITY, AND LESS TOXIC BY-PRODUCTS.

IF I HAD TO PICK A SINGLE AREA MOST CRUCIAL TO OUR NATIONAL COMPETITIVE POSITION WHERE NBS HAS A CENTRAL ROLE, IT WOULD BE THE AUTOMATION OF MANUFACTURING PROCESSES. IN ADDITION TO ENABLING THE STREAMLINING OF PRODUCTION-SPECIFIC ACTIVITIES--AS THROUGH THE MODULAR, GENERIC USE OF ROBOTICS--THE BUREAU FORESEES AUTOMATION OF THE VERY COSTLY OVERHEAD FUNCTIONS AS WELL, THROUGH THE USE OF SOPHISTICATED COMPUTERS. STANDARDIZED PROTOCOLS, ARRIVED AT IN CLOSE INTERACTION WITH INDUSTRY, ARE ESSENTIAL TO NATIONAL LEADERSHIP IN THESE ADVANCED ASPECTS OF MANUFACTURING. ADVANCED DATA PROCESSING STANDARDS ARE AN ULTIMATE GOAL ALSO OF NBS'S NEW WORK IN LIGHT-WAVE TECHNOLOGIES AND FIBER OPTICS, BROADENING THEIR USEFUL EFFORTS IN TELECOMMUNICATIONS. IN THE FIELD OF MATERIALS--TRADITIONALLY HAMPERED BY MANUFACTURING PROBLEMS--NBS HOPES EVENTUALLY TO DEVISE CERAMICS, POLYMERS, AND COMPOSITES CHARACTERIZATION METHODS AND STANDARDS SUITABLE FOR OUR WIDE SPECTRUM OF NEEDS, FROM CRITICAL MATERIALS SUBSTITUTION TO FUTURISTIC AIRCRAFT SUCH AS THE TRANSATMOSPHERIC VEHICLE.

ACCORDING TO ITS LEGISLATIVE MANDATE, THE MISSION OF THE NATIONAL BUREAU OF STANDARDS IS TO SUPPORT INDUSTRY AND COMMERCE IN THIS COUNTRY BY PROVIDING MEASUREMENT AND STANDARDS SERVICES. AS AMERICA DEPENDS MORE AND MORE ON THE SUCCESS OF INDUSTRY AND COMMERCE FOR HER ECONOMIC AND INTERNATIONAL SECURITY, THE BUREAU IS BOUND TO BE CALLED UPON TO PLAY A LARGER ROLE. FORTUNATELY, IT HAS A STRONG RECORD OF EXCELLENCE TO BUILD UPON. THE FUTURE WILL DEMAND OF IT, AS OF US ALL, A NEW LEVEL OF CREATIVITY AND A GREATER CAPACITY FOR INNOVATION. THERE WILL BE CHANGES. AT THE BUREAU THESE SHOULD BE DIRECTED TOWARD FINDING NEW WAYS TO

DISSEMINATE ITS SERVICES, EXPLORING THE POSSIBILITIES INHERENT IN COMPUTERS, DATA BASES, AND ELECTRONIC MAIL. WITH THE TREND TOWARD MORE ENCOURAGEMENT OF NEW ENTREPRENEURS BY STATE AND LOCAL ENTITIES, NBS CAN EXPECT SOME NEW CLIENTELE--HELPING STATE GOVERNMENTS TO PROVIDE PRODUCTS USEFUL FOR SMALL BUSINESSES. FINALLY, THE BUREAU'S CONTINUED EFFECTIVENESS WILL REQUIRE KEEPING A CONSTANT VIGILANCE OVER POTENTIAL NEW TECHNOLOGIES, RELYING ON ITS OWN STRONG SCIENCE BASE TO ANTICIPATE THE NEED FOR UNIQUE FACILITIES TO MEET IT.

MORE EXTENSIVE INTERACTION WITH INDUSTRY--INCLUDING SHARED FUNDING ARRANGEMENTS--IS A HIGHLIGHT OF THE BUREAU'S PRESENT AND FUTURE CONFIGURATION. I MENTIONED EARLIER THAT NBS BENEFITS ALREADY FROM VARIOUS MANIFESTATIONS OF INDUSTRIAL COOPERATION--AS DO ITS INDUSTRIAL PARTNERS. COOPERATION BETWEEN GOVERNMENT, UNIVERSITY, AND INDUSTRIAL RESEARCH AND DEVELOPMENT PERFORMERS--AND BETTER INTERAGENCY COORDINATION OF FEDERAL R&D ACTIVITIES--ARE UTTERLY ESSENTIAL TO AMERICA'S RETAINING AND ENHANCING HER ACCUSTOMED POSITION OF WORLD ECONOMIC AND TECHNOLOGICAL LEADERSHIP. IT IS PRECISELY BECAUSE OF ITS STRONG GENERIC SCIENCE AND TECHNOLOGY BASE THAT THE BUREAU IS ABLE TO STRENGTHEN OUR INDUSTRIAL POSTURE.

THE SCIENCE AND TECHNOLOGY COMMUNITY IN GENERAL MUST PRESENT A UNITED FRONT, MUST BE JUST THAT--A COMMUNITY, IN THE FACE OF COMPETITION. IT CAN LEARN A GREAT DEAL FROM THE NATIONAL BUREAU OF STANDARDS, WHERE SECTORAL STRENGTHS ENHANCE RATHER THAN IMPEDE PROGRESS.

Mr. WALGREN. Thank you very much, Dr. McTague.

I liked the voting with your feet characterization of what we've experienced with the National Bureau of Standards over these last number of years. And I think it's clear that there is a tremendous appreciation in the scientific and industrial community for the importance of their work and their contributions.

Throughout your statement you underscore how the Bureau can play right into where we think our strengths are, both in focusing on the possibilities of the frontiers of science and technology, and their being right at the nexus where these technologies are translated into actual commercial usefulness, and in a way which is not heavyhanded or driven by some very limited perception of direction, but rather by cooperative relationships and with a lot of interaction between universities and businesses and the Bureau.

Wouldn't that really, though, argue that if we really are going with our strengths that the Bureau of Standards should be faring better than it has in our budget allocations? And instead of being whittled away by the flat funding of recent years, it should be enhanced in view of the contribution that apparently we all agree it can make?

Dr. McTAGUE. Let me focus perhaps not first on the money, but on role and mission and how it is perceived. Are they doing an effective job; do they have the resources to be as effective as we, as a nation, need them to be?

Precisely because the National Bureau of Standards operates at the border between science and technology, and industrial usage, it is bound to be controversial if it's doing its job. Some will want to draw the line closer to commercial utilization and industrial activities; some will want to draw the line farther back toward basic research.

And I believe that as a result of this discussion, that will go on forever; perhaps the Nation's good has not been as well served as it might have been had we given—by we I mean both the administration and the Congress—more of a free hand to the National Bureau of Standards to help determine its own fate with, of course, quality control coming from close interaction with industrial and university consultants.

We all have our special favorite programs that we would like to see the Bureau doing. We have our favorite programs that we would like to see the Bureau not doing. And I have a suspicion that as a result of that, we may not have kept our eye on the long horizon as well as we might have.

Mr. WALGREN. In line with what you raise there—the thought that Congress has added a number of specific responsibilities to the NBS over the last several decades—I guess at bottom I wish things weren't a fight, because what I hear you saying is that since we have specific areas we think they should not be doing and into that falls Center for Fire Research and the Center for Building Technology.

In recent years, both programs have been disputed between the Congress on the one hand and the administration on the other. I don't think anyone would say that it is wrong for this society to decide that it wants to pursue fire research on the Federal level, or that it is wrong for this society to have a building research center;

particularly in view of the loss of life that we expect to happen sometime in the United States from earthquakes and the inherent costs of building codes and the like. Yet, we've had nothing but a fight on that even though under our system the Congress and the law ultimately—as reflected by acts of Congress and signed by the President—have legitimized those roles.

It seems sad to look back and say well, because there have been these differing views, we have hamstrung the agency that we wanted to do more for us.

Dr. McTague. I think I agree with everything you have said. It is quite appropriate and legitimate that we have these serious discussions on what the role of the National Bureau of Standards should be. Once enacted into law, we should carry out whatever the mandates are.

What I'm concerned about—and I'm not pointing a finger in any direction, we're probably all guilty of this—is that as a result of this serious discussion, some of the more long-term important aspects of the Bureau may have suffered, such as the importance of a very solid tech base.

Mr. Walgren. A——

Dr. McTague. A solid technological base, a solid science base of support.

Mr. Walgren. Well, let me ask you to just give us some of your perceptions on what the National Bureau of Standards can do in that area, in that long term area. I was thinking substantially of trying to direct your attention toward its role with respect to basic research, which may be a part of this technical base that you raise, or technical research at that point.

At first blush, you read the charter and you say gee, this agency is going to be a dull bird, you know? Who really cares about measurement anyway? And yet, when you look at the things that are enabled by the actions of the Bureau, you do start to sense the criticality of their mission and the great essential nature of it. If they don't do what they can do, lots of other things that would otherwise happen for the better will not happen at all.

So, I would like to ask you to tell us a little bit about your views of what the NBS can contribute in the area of basic research and the longer term contribution that they can make.

Dr. McTague. I think their great strength has been not doing basic research in isolation, or doing technologically useful standards work in isolation, but they make use of it as a two-way street. Let me give you two examples; one going one way and one going the other way.

Because of a strong program in fundamental solid state physics, they were able to be on the forefront of work in the Quantum-Hall effect, a very recent activity in condensed matter physics. Out of this will come, and is coming, a voltage standard of unprecedentedly high accuracy, several orders of magnitude more accurate than anything presently available. And that will have significant impact on many industries. That's because they were doing relevant and excellent forefront solid state physics.

Let me give you another example starting off in the other direction. They have been working for several years now on measurement techniques related to thin films. Because of the excellence of the people working in these measurement techniques, of course they have produced some important new tools for examining thin films which are so important to many industries, including the microelectronics industry. But also as a result of that there have been very substantial advances in our understanding of surface science.

So, the science to technology has worked as a two-way street there. These are relatively, by Government standards, very small programs. They've been excellent. I can only envision what would have happened had there been the opportunity to have had even more of these types of programs out there. They're not isolated. That's the important thing.

Mr. WALGREN. One of the most distressing things is that in some sectors of our scientific community the reputation of the Bureau is slipping. And some people have said to me, privately, anecdotally, that in their view over a 15-year or 20-year period, the scientific respect given to the Bureau is not what it was years ago.

Is this something that you are concerned about? And if so, what would you recommend as an antidote to that?

Dr. MCTAGUE. First, I think it's worth reiterating that there are substantial areas of truly world class excellence in basic and applied science at the Bureau. The total amount of that perhaps has gone down in part because of the decrease of almost 25 percent in staffing, that you've pointed out. In part because the public focus is not so much on the basic research end of it alone, but of the basic research as a part of the overall program. So, the basic research doesn't receive as much publicity.

There is a separate problem, I believe, and that is not unique to the National Bureau of Standards, and that is that it is very difficult to recruit and maintain world class scientists in Government-owned and Government-operated laboratories with the present salary scale, especially in forefront areas such as computing science and electrical engineering. And this is a problem that's bigger than the Bureau of Standards, and is something that we clearly must address.

Mr. WALGREN. I see. Well, let me recognize, on the minority side, Mr. Cobey. Mr. Boehlert had to leave and hopes to come back. But I would ask some indulgence from my friends on the Democratic side to turn to Mr. Cobey first and then to——

Mr. COBEY. I'll yield to the others, Mr. Chairman.

Mr. WALGREN. All right. Well then, in order of appearance, let me turn to Mr. Lundine.

Mr. LUNDINE. Mr. Brown said that meant that I had the best appearance because actually he showed up before I did.

Mr. WALGREN. Oh, I'm sorry.

Mr. LUNDINE. I don't think he minds if I question because I'll be brief. I want to follow up on one area that the chairman was propounding to you, and I want to see if I understand your point of view clearly.

If industrial innovation is to be the primary mission of the Bureau of Standards for the future, and we're confronted with a difficult budgetary limitation, are you suggesting that some of the worthwhile and justifiable activities like fire research and building, and those kinds of things, ought to be reconsidered because they're outside the mission?

Dr. McTague. The disagreement that has gone on between the administration and Members of Congress with respect to the fire and building programs is not related to budget. It is related to what is perceived as the proper role of the National Bureau of Standards. I doubt that that will be resolved in our lifetimes.

What I'm more concerned with is that as a result of this the budget has become hostage. There are tradeoffs made which I think no one would a priori decide would have been a good idea. That's more what I'm concerned about. I think the discussion is a valid discussion, and I don't see any signs of either side backing down on it.

Mr. Lundine. Neither do I, but I was hopeful that you would give me a good reason why one side should.

Dr. McTague. Which side did you have in mind?

Mr. Lundine. Well, I didn't have either one in mind. I was not acting like a lawyer who knew the answer to the question. I was really trying to learn something.

Mr. Walgren. Would the gentleman yield just for a thought?

Mr. Lundine. Certainly.

Mr. Walgren. And that is, if it isn't a budget matter, as you say, then why are there fallouts from the resolution, whatever it is, of whether or not it should be doing the building and the fire research? Can't the administration somehow or another fence off this question of whether or not between it and the Congress we should do these kinds of things, and treat the budget of the Bureau, as an intact issue which they want to maximize to its potential, if, as you say, it is not a budget matter?

Dr. McTague. Well, let's take a look at what happened this year in a concrete case. The administration proposed the construction of a cold neutron facility on the existing and excellent reactor at the Bureau, and which has a superb staff of scientists. Everyone is in agreement that this was a very high priority item, appropriate to the role of the Bureau, and involving a large amount of cooperation with industry and universities.

It was put in the budget that we submitted to Congress. The fire and building predictably were not. When it came up to Congress, then in the ensuing freeze scenario, there was a trade-off made that I don't think anyone would have wanted to make. I have a suspicion that in another year it would have turned out in a different manner.

But as a result, there's no question that science got delayed, good science, very solid world-leading science in an important industrial area.

Mr. Lundine. One of NBS' historic responsibilities has been in the area of evaluation of engineering data and maintaining the data base on physical and chemical properties of certain materials. This is an area that the National Academy has said that we're falling behind other nations.

Do you agree with that, and do you have any thoughts on how we could address this problem more effectively?

Dr. McTague. First let me say that I think the Bureau does a very good job in this area. It's an area which doesn't have the glamour of some other areas. There are no Nobel Prizes given for engineering data bases that I'm aware of.

Several of these data bases play important roles in our industrial position. The important thing is that we find means for determining what our priorities should be on data bases, how much should we have, which ones should we have.

One of the quality control criteria here is how willing is industry to invest in the maintenance and nurturing of these data bases. That's one measure. The other of which is how broadly applicable are they? Are they broadly enough applicable that they should have substantial Federal responsibilities? So that requires constant surveillance, and perhaps we have not done as good a job as we should have.

Mr. LUNDINE. Thank you, Mr. Chairman.

Mr. WALGREN. Thank you, Mr. Lundine. Mr. Brown.

Mr. BROWN. Let me explore just a little bit further, Dr. McTague, this same question of how we resolve the problem with the Bureau based upon the administration's objections to the fire and the building program, and I presume the computer institute falls within the same category since the administration has not wanted to fund that particularly.

I agree that this has harmed the underlying budget of the Bureau considerably. In the usual fashion of a politician, I am wondering why we can't resolve that in some reasonable way without either the Congress having to backtrack on its commitment to what it considers programs vital to the health and safety of the Nation or the Administration backtracking on its philosophy that these are inappropriate for a Federal role.

We've had a number of parallel situations, and I could list, for example, the spinoff of Comsat, which was originally a Federal research program and then became a flourishing commercial enterprise; the more recent spinoff of Landsat, and in fact the administration's desire to spinoff the meteorological satellites. And there are probably other examples of where a program that was initiated as a result of Federal research was spunoff to a more appropriate management type.

Why couldn't we do the same thing with the fire research program or the building research program? Why couldn't we do a little ground work to see what institutional arrangements would be appropriate to fulfill this admittedly important role and go about setting it up?

Now, the National Science Foundation has funded a number of important activities under the generic title of engineering research facilities. We've set up computer centers all over the country. Generally the pattern is we find a sponsor that has acceptable qualifications, we provide them with a 5-year declining funding in order to do the job, and we wish them well. That means they have to become self-supporting after a period of time.

Well, on a program as vital to the health and safety of the Nation as research on fire and research on building standards, in which there is a Federal commitment in many ways, why can't we exercise similar ingenuity in order to maintain this program and see to it that the national needs are met, and forget about this ideological stuff that seems to be the hangup here?

Dr. McTague. I think the suggestion for looking for more flexible means of solving this problem, such as the one you've just named, is an excellent one. I wouldn't want to commit myself on the details of whether this would be the best way to do it, but certainly I know of no one who's arguing that the nation as a whole should not be pursuing fire and building research.

Mr. Brown. I don't either.

Dr. McTague. The question is how to get it into an organization that we all agree can do the job and is appropriate to do the job. The possibility of flexibly passing it off is something worth exploring.

Mr. Brown. In the case of Landsat, which is the largest spinoff, we've actually subsidized a private corporation to the tune of several hundred million dollars, in effect, bribing it to take Landsat off our hands. I'd be willing to do the same thing with the meteorological satellites if we could find some acceptable way to guarantee the continuity of data. Maybe the television networks could set up a nonprofit corporation to run them, since they're the ones that use the data most, as long as we had some commitment to continuing excellence and the basic research that stems from systems of this kind.

I would very strongly recommend that in your office, since I think you have more creative imagination than OMB——

Mr. Lundine. That isn't saying a hell of a lot.

Mr. Brown [continuing]. You make an honest effort to come up with something like this and we can see some progress. I hate to see those vitally important programs, which got cut as a result of this, get cut. I think no member of this committee would hesitate to provide full funding for everything that was recommended there. And yet, we don't like to get slapped in the face by an administration that says the programs that we have thought were vitally important for years aren't worth a tinker's damn, which, in effect is what your budget proposal says.

Dr. McTague. Well, we would never slap you in the face, Congressman, but this is an honest difference of opinion on the appropriate role of the Federal Government and not a value judgment on whether these programs are important for the country. The question is whether insurance companies, for example, who are one of the main beneficiaries of, in particular, fire research, should they not be playing a significant role, for example.

It is not a question of whether this research should be done for the Nation as a whole.

Mr. Brown. Well, I can't think of the appropriate word, but to expect the insurance companies to come together and take over a program that is doing very well with complete Federal funding is not realistic.

You have to work with those companies and reach some sort of an agreement that there will be a transitional phasing in, in which they're going to be asked to participate in, and I think they would. But there's going to have to be some initiative from the Federal Government to do that.

Similarly with building research. You know that in each case what we have is a highly fragmented industry with very little capability to work together to achieve this kind of research. They're not going to volunteer to do it unless they're given some assistance and some kick in the pants in order to do it.

Thank you, Mr. Chairman.

Mr. WALGREN. Thank you, Mr. Brown. Mr. Cobey.

Mr. COBEY. Thank you, Mr. Chairman. Dr. McTague, on the subject of the cold neutron source facility that has already come up, your office has gone on record in favor of constructing this at NBS. I just wanted to hear your comments as to what would be the advantages of doing so, and also the consequences of not doing so. If you could give us your thoughts on that.

Dr. MCTAGUE. The so-called cold neutrons, which are neutrons with rather long wavelengths, have the unique capability of exploring matter on the distance scale of the order of hundreds of angstroms. On this scale one can examine defect structures in materials; one can examine the configurations of biological molecules, in vivo; and one can examine the configurations of polymer molecules, both in solution and uniquely in the bulk, to look at the properties of single polymer molecules in a bulk sample.

As a result of this there is very lively research going on in those facilities in the world that have this capability. The leading facility is in the Institut Laue Langevin, in Grenoble, which is funded by a consortium of the British, French, and German Governments. They are world leaders in this area precisely because they have such a facility there.

We have some facilities at the Oak Ridge National Laboratory which are inadequate to the national need, but which are very effective and very heavily utilized by both industry and academe.

The creation of a facility on the NBS reactor, whose core happens to be uniquely well configured for such a facility, would greatly increase the Nation's capabilities to study such things as defect structures and polymers in the bulk.

Mr. COBEY. Could you address the consequences of not going forward quickly?

Dr. MCTAGUE. Well, let me give you an example. One of the more important areas that we all see in the areas of materials are ceramic materials as substitutes for strategic materials, et cetera. Understanding how to manufacture ceramics well is a difficult problem because of the defect structures which occur with present manufacturing mechanisms.

If we don't have the tools to examine the defect structures in order to learn how to manufacture these materials, we will, for the foreseeable future, have great difficulties in, for example, our strategic stockpile problems.

So, it's a very, very relevant area, and one in which this relatively modest addition to an facility will be, I think by everyone's judgment, exceptionally cost effective and exceptionally useful.

Mr. COBEY. Why is the cold neutron at NBS and not at DOE at Brookhaven National Lab? The subcommittee understands that the Brookhaven Lab has the capability for a facility. Would you address that please?

Dr. MCTAGUE. Both reactors have the capability to add cold neutron capabilities to their existing reactor. The two reactors are rather different. The one at the Bureau of Standards is of relatively lower power, but because of the unique configuration of the core, it has the opportunity to take large beam lines out so that one gets fluxes which are very high.

The Brookhaven core is a smaller core, but of relatively higher local flux. So, there is utility in eventually putting such capabilities probably on both reactors. Indeed the Seitz-Eastman study, done by the National Academy of Sciences, to examine future needs in material science facilities recommended the creation of such facilities on both sources. The question is relative timing and the competition with other programs at each of the laboratories.

Mr. COBEY. Thank you, Dr. McTague. Mr. Chairman, I yield.

Mr. LUNDINE [acting chairman]. Mr. Mineta.

Mr. MINETA. Thank you very much, Mr. Chairman. Dr. McTague, I'd like to change the focus a little bit and talk about the future; 15, 20, 50 years from now, where are we going? What I see happening here is the administration putting some starch on the agency, putting some ingredients in to shrink it. And yet, at the same time, saying well, there are a lot of these things that ought to be done by private groups; the National Association of Zipper Manufacturers, the Center for Research Among Manufacturers, or whatever.

I'm just wondering, given the fact that there is some constriction about what's happening with professional or the GS scales as to whether or not we're going to have an agency in 5, 10, 20 years from now, if we're going to start squeezing it right now. We're seeing the squeeze with GS–11's to GS–15's, and we're not going to have the McTagues coming along who we want to be able to have in the Bureau because they're going to be off doing something in a more attractive setting.

I'm wondering whether you or your office have given some thought to that.

Dr. McTAGUE. Maybe the problem is you'll end up with too many McTagues, too many people who push papers instead of doing the science like we used to.

Mr. MINETA. Well, sometimes I wish we had more McTagues.

Dr. McTAGUE. You've hit on a real problem, and that is the ability to attract and retain the best scientists in our Federal laboratories. We simply must do better. The military has great difficulty in their laboratories in attracting electrical engineers. The Bureau has great difficulty in attracting some computer scientists.

It's amazing in fact, though, how well the Bureau has done at recruiting in which people will come and take a 40-percent cut in salary because they like the kind of activities that are going on in some of the areas at the Bureau. We shouldn't make these demands on people, though. They shouldn't have to make such choices.

I think it's an area that Congress should take a look at in a wider perspective than just the Bureau. It's a big problem. It's a problem over the whole of the Federal laboratory system which is immense.

Mr. MINETA. Dr. McTague, may I follow up on that point? In the chairman's opening statement he said something about, since 1965, the Congress has mandated some number of programs, 20 or whatever for the Bureau to perform.

Should there really be some kind of a block grant approach to that so that we can be delegating to the agency where that emphasis ought to be?

Is this something that we're getting, between not only squeezing the number of types of people, but we're being too specific in terms of the kinds of things the Bureau ought to be doing?

Dr. McTague. I think that's true. I think the question is, how can we find a mechanism which preserves accountability yet avoids micromanagement on the part of whomever. We might take a lesson from looking at the management of the weapons laboratories in DOE—Los Alamos, Sandia, Livermore—who receive funding in very broad areas and are judged on performance.

Mr. Mineta. Not only broad areas, but the amount of money, Dr. McTague, you can't compare in anyway. What's the total R&D going to military research? Seventy percent of the Federal R&D dollars? Eighty percent?

Dr. McTague. Seventy.

Mr. Mineta. Seventy percent. So the civil sector of our economy is this big—military is this big—but in terms of the amount of research, military is getting this amount and civil research is getting this amount. So, from that perspective, I don't think DARPA or anything else is a good example of a block grant approach of letting them be innovative.

Dr. McTague. Well, let's be fair there in terms of numbers. Civilian research in the United States is at a significantly higher level than military research. The overall R&D budget in the United States totals——

Mr. Mineta. IBM spends more than the Federal Government does.

Dr. McTague [continuing]. $120 billion, of which about $32 billion is defense research and development. Of that, in fact—it's probably a misnomer to call it research and development. It's research, development, testing, and evaluation. So a significant fraction of that, for example, is the first several flights of an MX missile because of the way counting is done.

I don't think there is an imbalance in the amount that the country as a whole spends on defense research. I think we have a problem in the effectiveness with which we, in the Federal sector, spend money both on defense research and on research that is oriented toward industrial competitiveness and other national goals.

Mr. Mineta. I guess being on Public Works and Transportation, there's a phrase there that's referred to, no new starts, whether it be urban mass transit programs, whatever.

programs, whatever.

Is this something that we're finding also in the science area, especially as it relates to NBS? I mean, you talked about the excitement that may be forthcoming in the area of biotechnology, and then you say, but, gee, we also have that crucial area of automation and manufacturing processes.

Well, those are great, and we've got to do that. But there's a crunch on. And I'm just wondering whether that crunch isn't eliminating the ability even to be innovative so that you have interagency cooperation between an NBS and NIH, or NBS and whomever.

What can we do to sort of knead that relationship between NBS and other agencies within the governmental structure? You mention the exemplary relationship between NBS and industry. Well, what about NBS and other governmental agencies?

Dr. McTague. I'd like to comment on both of the facets that you just discussed, the first of which is no new starts. During this time when we are focusing appropriately on the problem of the Federal deficit, in this first year of approaching it as a high national priority, we rightly took emergency action. Emergency action included the freeze and in effect a policy of no new starts.

If that continues in the future, I think we will be sacrificing our industrial competitiveness and national security over the coming generations. In whatever budget constraints we must operate in, we must constantly make priority choices. We must face toward where we have to be 10 and 20 years from now. Last year isn't good enough for 10 or 20 years from now. I'm not talking about the amount of money that we spend. I'm talking about how we spend it. Within any budget scenario we must make priorities.

Mr. Mineta. Thank you very much, Mr. Chairman.

Mr. Walgren. Thank you, Mr. Mineta. Mr. Valentine.

Mr. Valentine. Thank you, Mr. Chairman. Dr. McTague, I want to ask you maybe just one question, and I think you have perhaps answered it partially, but maybe I'll give you an opportunity to answer it in a different way.

I suppose that the Bureau of Standards is one of the oldest agencies of the Federal Government, in that we decided pretty early on that we needed to be a nation of standards, and that it was necessary that a ton be a ton and the same measurement in Massachusetts as in South Carolina or North Carolina.

I think it's a great agency, and I want to, for the record, mention an article which appeared in a recent issue of Smithsonian magazine which I thought was very, very interesting and very complimentary.

But if you didn't have to deal with politicians, political considerations, or directives from the executive branch, and if you could just sign a document and issue a directive that would bring about an improvement in this agency—and if you could say in a few words—what would it contain? What would you do to make it better other than raise everybody's salary or spend a lot more money that we don't have—aside from political considerations?

Dr. McTague. I think I would give the Bureau broad mandates to provide standards services and the relevant underlying technological base for the Nation's industrial competitiveness and national security. I would do it in a document that would be shorter rather than longer, and require performance evaluation for the funding that they're given rather than excessively detailed line item appropriation.

Mr. Valentine. Thank you.

Mr. Walgren. Thank you, Mr. Valentine. Mr. Ritter.

Mr. Ritter. Thank you, Mr. Chairman. I'd like to commend the gentleman at the witness table for his incisive testimony and his incisive response to these questions. I think some of these questions have been tough and they've been good questions.

If the Bureau is a potential model for Federal national laboratories working to enhance the industrial base and the industrial competitiveness of America's economy, is it possible, in your opinion, to extend from the Bureau some of the same characteristics to some of the other Federal and national laboratories to perhaps reorient some of these missions toward the mission of enhanced industrial competitiveness?

By the way, the Science Policy Task Force this week, I believe, is considering this question in some detail.

Dr. McTague. I think it's highly appropriate and timely that that activity is taking place. A good context in which to put this is the recent Packard Commission report on the role of the Federal laboratory, the role and mission of the Federal laboratories.

As a result of the recommendations of that Commission, all Federal laboratories have restated what they consider to be their missions and goals. And I think this has been a useful beginning. It's only a beginning, however. There is a fair amount of cultural change that needs to take place both within the laboratories and in Washington to make sure that we, as a nation, get the maximum total return from our very large Federal investments in research and development.

This doesn't mean that all of the Defense Department laboratories or the Department of Energy laboratories should all of a sudden decide to become vassals of General Motors or Ford. What it means is that they should consider the relevance of the strengths that they have because of their mission or roles. The relevance of those strengths to other national goals, such as industrial competitiveness, how to implement this overall vision without destroying the role character of the laboratories or without interfering with what our industrial perogatives is a very delicate one, and one which cannot avoid human judgment at all levels. But it will be done if we show the commitments to reaching that goal.

And I think, as my boss Jay Keyworth would put it, the hot breath of the Japanese on the backs of this country right now is very salutary for us to get maximum return out of our resources.

Mr. Ritter. You know, I used to think it was hot breath on our backs, but I think it's the heat stirred up by their frenzied feet out in front. I think that's a very interesting point. When you come right down to it, it would require the cooperation of the executive branch, it would require the cooperation of the Congress, obviously the leadership within the laboratories would be required, and it would require a substantial input from the private sector itself.

I look forward to these Science Policy Task Force meetings in a way to perhaps come up with some of the routes and answers. I think that Dr. Keyworth himself and OSTP have really set the road map, so to speak, and now is the time to start moving along the road.

Thank you, Mr. Chairman.

Mr. Walgren. Thank you, Mr. Ritter. Well, on behalf of the committee let me thank you, Dr. McTague, for your appearance and for being a resource to us. We appreciate your responsiveness.

Dr. McTague. Thank you.

Mr. **Walgren**. The next witness is Hon. Clarence "Bud" Brown, Deputy Secretary of the Department of Commerce, who we all know in this body as a friend and former colleague before he took a different course.

Mr. **Ritter**. Before he made the mistake of running for higher office.

Mr. **Walgren**. Well, it all turned out well, whatever it was. Welcome to the committee, Mr. Secretary. We appreciate your being here.

Mr. **Brown**. Mr. Chairman, thank you very much.

STATEMENT OF CLARENCE J. BROWN, DEPUTY SECRETARY, DEPARTMENT OF COMMERCE

Mr. **Brown**. Mr. Chairman, members of the subcommittee, I appreciate this chance to discuss the present and the future role of the National Bureau of Standards. Today, as never before, advances in science and technology are the key to the competitiveness of this Nation. It's estimated that the world's body of scientific knowledge doubles every decade. One of the folks in our department says that 90 percent of all knowledge, all scientific knowledge has come into existence since World War II. That statistic always offends me because that's the time I got my liberal arts degree in college and I didn't understand the first 10 percent.

But suffice it to say that we are moving very rapidly in development of scientific knowledge. The proliferation of knowledge is constantly producing new technology. In general, technology is being produced so rapidly that it becomes obsolete on average within 5 to 7 years. In electronics it's 3 to 5 years. Some technology is obsolete before it's even off the drawing board. In fact, drawing boards, themselves, are becoming obsolete due to the advent of computer aided design.

With the coming of low cost computer telecommunications networks, engineers, scientists and business people in every part of the globe now have instant access to the latest technology and production techniques. Knowledge is replacing raw materials and labor as the primary source of wealth, thus allowing even resourceless nations to create their own comparative advantage and overleap more highly developed and resource blessed countries.

In this way, Japan has displaced America, or at least attacked it, as the world's leading automobile manufacturer. It has displaced Germany as the world's major cameramaker, and it has displaced Switzerland as the world's premiere watchmaker.

It is for these reasons that this administration and the Department of Commerce, in particular, have given priority to improving the health of the U.S. scientific and technical enterprise in America.

The National Bureau of Standards fills a special niche in U.S. science and technology. Its work concentrates on helping this country improve productivity and quality control by using new and better measuring techniques and standards. Like all organizations, the Department of Commerce and NBS should be, and are, looking ahead at what is in store for us in the future, what the country's measurements needs are and will be, and where the Federal Government, our department, and NBS can play a vital role. Your hearings on this subject are timely and welcome to those of us who are reviewing the status of this important Federal agency.

We are all concerned with the U.S. trade position. U.S. companies have not been doing well competitively in a number of product areas. We have lost, at least for now, some key markets. But I would like to suggest that we look at more than just the negatives. This economy has seen millions of jobs created, millions more than have been lost due to our competitor's relative successes.

Since 1982, 8 million new jobs have been created. In 1984, we were creating jobs at a rate of 300,000 a month, which is more than the European Common Market has created in the past decade. Between 1950 and 1970, 75 percent of all new jobs were created either by big business or big government. But over the past 4 years, the Fortune 500 companies have lost over 2 million jobs, while at the same time businesses less than 10 years old have added almost 1 million new jobs.

These businesses are mostly small, dealing in new goods and services, and high technology areas. Such a record suggests that we excel like no other nation when it comes to high technology product areas.

This Administration understands the frustration involved for those who have lost jobs due to foreign competition, and we are taking stronger steps to assure that American products and manufacturers are not discriminated against. The clamor for protectionist measures for our industries has gotten noticeably more vocal of late. But trade protectionism is not the magic answer because other countries will react by instituting their own protective measures.

Moreover, protectionism has the insidious effect of reducing our competitive efforts further by reducing pressures to exert efforts toward improving the quality and performance of our products and our processes through research and technological advancement.

We have seen instances where industry should be looking ahead and investing in research and development for the future, but instead have become distracted by unfair trade competition. In the long run, protectionist measures as a substitute for technological improvement have eroded the strong technological foundation so essential to our economy.

Technology is the most important factor in determining the international competitive position of the United States today. The conclusions of the President's Commission on Industrial Competitiveness confirmed the seriousness of the deteriorating international competitiveness of U.S. firms and the critical nature of technology in recovering our position of economic leadership. Technology contributes to new products and gives existing products better performance attributes, such as higher quality and reliability. It also leads to lower production costs.

Industry concentrates on technology. In fact, more than 50 percent of the R&D undertaken in America is funded by private industry—some $53 billion in 1985 as compared with roughly $50 billion spent by Government on R&D. However, underlying all technology is a base of science, the sum of all scientific and technical knowledge. And that's where the Federal Government has an essential role; supporting fundamental research in science and engineering.

The private sector simply lacks sufficient incentives to broadly support basic research that is far from the marketplace. When the Government supports this research, the results reside in the public domain, available for all to use.

Another public domain component of technology is so called infratechnology. This is the organized body of scientific and engineering knowledge for enhancing scientific research and technology-based economic activity. The National Bureau of Standards is the major source of infratechnology in the form of tables of reliable data, predictive equations and models, and well documented measurement methods, techniques and standards.

Let me put into context the importance of measurements to those industries where the application of advanced technologies is producing high rates of economic growth currently.

In 1983, across the whole of the U.S. economy, $163 billion was spent on measurements, or 3.5 percent of the Nation's GNP. Nearly one-half of that total was concentrated in 20 sectors of the economy, including electronic components where measurements account for 20 percent of that industry's labor costs. NBS plays the central role in developing the basis for all these measurements. The United States needs these measurements for new product development, efficiency, and quality assurance in manufacturing, and equity in trade.

America faces the task of maintaining the strength of our technology base and focusing its use for the maximum benefit of domestic industry at a time of mounting Federal expenditures. One solution is to increase private industry involvement in the development of technology components. NBS has an extremely strong industry involvement. Dr. Ernest Ambler, the NBS Director, will address that in more detail in his testimony following mine.

Another vehicle might be proposed legislation intended to improve the transfer of technology from Federal laboratories, like NBS, to commercial organizations. The proposed Federal Laboratory Technology Utilization Act of 1985, H.R. 695 and S.65, would authorize Federal labs to enter into cooperative R&D arrangements, to license patents, to retain royalties, and to share royalties with Government employees who made the invention.

Making Federal research facilities available also can provide important advantages to U.S. companies without increasing the burden on Federal finances. I refer to those facilities that would be too expensive or impossible for a private firm to duplicate. This could be either for cooperative research or for the development of proprietary data.

While most of the cooperative work at NBS results in data that will reside in the public domain, last year NBS started to allow the use of its special facilities for proprietary research by private U.S. firms on an as available and fully cost reimbursable basis. Several U.S. firms, large and small, already have made use of the NBS nuclear research reactor, large scale environmental test chamber, and combustion calorimeter. Looking toward the future, I think this is a healthy trend for NBS and, I might say, for other Federal facilities.

The results of cooperation on R&D are yielding some positive results in other areas, results that are both short- and long-term payoffs. The recent changes in antitrust laws have permitted joint R&D by companies that would have been unthinkable just a few years ago. Now, under certain conditions, companies can pool their knowledge and resources free of antitrust challenges that might have come previously.

The Department of Commerce, like the rest of the Federal Government, has had to make some difficult choices over the past several years. We have to keep Federal spending down. Recognizing the importance of NBS to our economy, we have made every effort to provide this agency with the resources necessary to do the measurement research and standards work industry sorely needs.

In fact, and I want to refer you, if I can, to chart 1—I hope you can all see it—chart 1 shows that NBS has fared well when compared to the Department of Commerce as a whole. While the rest of the Department has seen budget reductions of 18 percent—and I might say parenthetically that we think the department is more effective now than it was 4 years ago in spite of those reductions—we have been able to keep the Bureau's funding just about even during the 2 budget years I have been in Commerce. And I'm confident that NBS is a more effective and productive organization now than it was 2 years ago.

There is another comparison that merits this subcommittee's attention. The second chart lists the new initiatives contained in the last two NBS budgets submitted to the Congress. The final appropriation in fiscal year 1985 and the fiscal year 1986 House allowance both funded only about 40 percent of the dollars requested by the administration for new NBS programs.

In my role as manager of the Department of Commerce budget, I often have to compare constraints placed on me against the expectations of client groups. For example, the National Conference of Standard Laboratories made a valuable contribution 3 years ago when it identified and ranked about two dozen technical measurements in standards areas totaling $13 million that NBS should support. They claimed NBS should start work on all of these right away.

This is extremely difficult in even a less restrictive budget climate. But we were able to move incrementally. The NBS process and quality control initiative did allow undertaking research on the two highest priority projects in 1985 and the next three highest in 1986.

The last comparison I'll make illustrates the difficulty NBS faces in planning future programs. Some people say that NBS should be a standards laboratory in a narrow sense and respond to particular needs of industry as problems arise. Others say that NBS should be a broad and future oriented lab and address the measurement related problems it sees U.S. industry facing ahead as it works to improve U.S. competitiveness. I think the latter mission is far preferable for a technological nation competing in a global economy.

Primary standards, like mass, voltage, or length, are important but relatively straightforward and not a rapidly changing technology. The continuing needs are mainly to increase the accuracy of measurement methods. Scientists know the approaches to follow.

But an emerging technology, like fiber optic communications, is developing with rapid changes in its technology. In this case, NBS has been asked by industry to help bring order to the market of buyers and sellers by forging a consensus on standard methods of measuring fiber optic attenuation, power, and other technical parameters.

As the next generation technology becomes apparent, NBS is continuing such efforts in single mode fiber and integrated lightwave optoelectronics. There is always an increasing demand for new measurement information. This presents a true dilemma for those of us making decisions about the future for NBS. Science and technology still demand maintenance and improvement of mass, voltage, length, and other traditional measurement standards, even while NBS has to undertake research efforts in the emerging technologies.

As is the case in managing a business or any other organization, in managing scientific laboratories, like NBS, I naturally come across some issues on which managers may disagree.

One issue concerns the timing for major efforts in support of particular technologies. Since the diffusion of innovations into successful commercial trade usually follows long and uncertain paths, at any one time there are many technologies or products seeking research or standards support.

The difficult decision is determining where and when the lack of such support will be a significant barrier to commercial progress. For example—and I go back to fiber optic technology—that technology has been with us for a dozen or more years. But only in the last few years have conditions been appropriate for widespread use in telecommunication systems, and only recently have industry's needs for measurements and standards become focused.

Had the Government made a big research investment in fiber optic technology beforehand, we might have wasted both time and money on a not yet mature technology. In the same respect, if we try to develop standards, even voluntary standards, too soon, we run the risk of retarding innovation in an emerging technology. But if we wait too long to do the measurement research and standards work, we run the risk of missing out on production efficiencies and losing our share in the marketplace. So, these are difficult decisions.

Another difficult issue involves setting priorities for allocating limited resources between technologies. As this subcommittee undoubtedly has concluded, even informed scientists and managers are likely to differ in their priorities.

For example, my third chart shows the variation in ranking of NBS initiatives during the fiscal year 1987 budget process by members of the NBS visiting committee and by NBS, itself, in trying to set those standards in their own order. While there is a consensus at the highest and lowest rankings, different criteria and perceptions result in varying priorities that must be resolved during the budget process.

Because of the Federal deficit, the total budget in the near term for NBS must remain stable. That means it is necessary to eliminate some programs in order to undertake research in new problem areas. This is the background for the requested termination of the fire and building research programs proposed in recent NBS budgets.

While these programs have been carrying out good research and providing useful services, the technology is not changing as rapidly as it is in many other fields. Nor are these areas subject to intense foreign competition. Moreover, there are areas where the private sector should be—they are areas where the private sector should be doing more with its own financing.

The proposed reduction of the NBS program in domestic computer standards is based upon the belief that the U.S. computer industry is vigorous enough to pursue these areas itself, and to do so with private financing. As difficult a process as this is for NBS, and as difficult as it is to get affected user groups to shoulder a burden—as was suggested by my namesake on the committee—rather than accept taxpayer largesse, it is necessary if limited public resources are to be available to support new and faster moving, and perhaps in some instances, more valuable technological areas.

As your letter of invitation pointed out, NBS must do research now in order to support industry efforts to be competitive over the next 15 years by providing the standards necessary for those emerging industries. Let me mention several of these future opportunities for industry I see developing during the next decade.

Lightweight, high performance composite materials will allow commercial and military aircraft that consume less fuel and use less critical materials such as titanium. Integrated optical electronics will allow higher performance communication and computer systems at lower cost.

Developing a cold neutron research facility will provide an outstanding research tool for U.S. scientists and material science, such as ceramics, composites and polymers, and for uses in communications, electronics, medicine, and other fields.

Biotechnology processing techniques will provide many opportunities for new products and more productive biochemical manufacturing processes with health and agricultural applications, as well as industrial materials uses.

Effective network connection methods for advanced information systems in manufacturing and telecommunications will lead to commercial opportunities for U.S. firms, small and large.

Advanced ceramic materials will lead to lighter automotive engines with higher operating temperatures and far greater fuel efficiency.

With your permission, I would like to show you now a brief videotape that explains industry's needs for NBS' support in this particular area.

[Videotape shown.]

HIGH-TECH CERAMICS

AT NBS

KEY TO THE FUTURE

Narration Script

Shot of artificial heart	Inside the artificial heart are ceramic valves....
Shuttle taking off	On the wings of the space shuttle are heat protecting ceramic tiles....
Shuttle landing	But these are just two of thousands of high-tech ceramics that will likely guide a U.S. approach to economic health in the year 2000.
	STAND UP
Super: Allen Eustis	You and I are more familiar with a kind of low-tech ceramic -- they've been around for thousands of years. The buildings we live and work in are made of brick and we cook with heat-resistant ceramic pots. The word ceramic comes from Greek "Keramos" and it means literally burnt stuff.... But making commercially usable high-tech ceramics is a lot more of a delicate science than just shoving a pot in an oven...and hoping you come out with more than burnt stuff.
Computer Graphics	High-tech ceramics start out as a fine powder. Chemicals are added, and pressure applied to compact the powder into a green unfired ceramic... then in a process called sintering, a high-tech ceramic is heated to thousands of degrees in an oven...this welds the particles together into a finished high-tech ceramic...a product that can be stronger, more light weight and heat resistant than any metal.

w/s Powder lab	In the Advanced Ceramics Lab of the National Bureau of Standards, an agency of the Department of Commerce, scientists are beginning to unravel the many mysteries of making uniform high-tech ceramics...products that are already of immense value to U.S. industry....
Super: Dr. Stephen Hsu, Materials Scientist	Dr. Stephen Hsu: "Well, we are here at NBS doing state-of-the-art ceramic processing research to characterize different materials and to provide an understanding of how advanced ceramics are formed so that we can develop standards for the industry. One of the key areas is really the reliability of advanced ceramics and here the reliability has to be tied in very closely with the standards research and this is exactly what we are engaged in doing."
Shots of Katherine in Ceramics Lab	Researching each stage of the ceramic process, National Bureau of Standards scientists are learning, for example, how the size and surface area of ceramic powder particles affect the quality of the final product...uniformity and purity can be especially important in the ceramics used to make tiny computer chips....
Shots of woman using computer plotter of phase diagrams	Another essential facet of ceramics research here involves the compilation of thousands of chemical road maps called phase diagrams. These thermal blueprints tell engineers how different elements react under the intense heat required to produce high-tech ceramics.

	Each phase diagram represents some $50,000 of research from university, industry, and government laboratories. Right now, industry needs about 20,000 diagrams critically evaluated. The National Bureau of Standards is cooperating with industry to do just that, putting a billion dollars worth of research to better use.
Super: Dr. John Hastie, Research Chemist	Examples of industries that have contributed already to the program are the major automobile industries, oil industries, as well as conventional ceramic industries and companies like 3M, ATT, so it's really a broad spectrum of American industry that has a need for phase diagram information and is willing to contribute financially to the program.
Computer graphics	Shipments of advanced ceramics by the U.S. in 1980 were estimated at $1.5 billion...that figure will likely climb to $7 billion by 1995. Currently controlling the world market, Japan's $1.9 billion high-tech ceramic business in 1980 may well reach $9 billion dollars by 1995.... If the U.S. is to compete with Japan, measurements and standards calculated by National Bureau of Standards scientists will be vital to industry. There will be $29 billion in worldwide sales of high-tech ceramics in the year 2000...if the U.S. loses its share of the market somebody will surely be there to take its place.
	For the National Bureau of Standards, I'm Allan Eustis.

Mr. Chairman, once we make those hard decisions for NBS between technologies and when to move ahead within certain areas, the Bureau must have not only the financial resources, but also the pool of talent needed to get the job done. The experience at NBS for the past years is instructive. Bureau managers have found the market for electronics engineers and computer specialists extremely competitive, with top notch researchers hard to come by. It has been relatively easier to recruit chemists and physicists.

NBS also has had considerable success in bringing in materials scientists and engineers, especially in the area of ceramics, where there is only a small source of talent to draw from. Even in the most competitive fields we know that some of the best and brightest researchers are attracted to NBS because it has the reputation as a superior research institution that specializes in technical excellence.

The net combination of aging, turnover, and numerous management actions is that since 1980 the average age for NBS employees has declined slightly, with the most recent calculation being approximately 42 years. In fact, the visiting committee for NBS that advises the Secretary of Commerce and myself has taken note of the Bureau's personnel situation in recent reports to Secretary Baldrige.

Where 3 years ago this group of outside advisers was warning that the Bureau staff was spread very thinly and needed stability, in the most recent report to the Secretary, the visiting committee said that management and staff at NBS were strong. Their general assessment was that—and I quote—"The National Bureau of Standards is in good shape. The quality of the science and engineering is high, morale is good and the equipment is adequate."

I take as an indicator of the Bureau's personnel situation the staff's continued recognition by others. For instance, just last week NBS researchers received 8—not 7, there is an error in the testimony—8 of the 100 awards given annually by Research and Development magazine to honor the most significant, new technical products of the preceding year. This was the most awards given to any competitor, including some of the top companies and institutions in the United States as well as Japan. Our nearest rivals were Hitachi, with six awards, and Bell Laboratories of AT&T with six awards. And many other more famous research activities in the country had considerably less.

I've attached to my statement, for inclusion in the record, a letter from President Reagan to NBS Director Ambler congratulating the Bureau on this recognition. I should also mention two other top awards won by NBS staff. Dr. Johanna Sengers, a physicist at NBS, received the top 1985 award from Women in Science and Engineering, WISE, in the Federal Government; and Mr. Judson French, Director of the NBS Center for Electronics and Electrical Engineering received the Presidential Distinguished Rank Award, the highest award in the Federal civil service. These awards are only a small number of about 80 received by NBS staff from outside professional organizations last year. We think the staff is strong and competent.

NBS has a special mission as the only Federal agency charged with directly serving U.S. industry. It is doing a fine job and helping this country to be more competitive by advancing measurement science and technology and providing critical services. I intend to do everything I can to make sure it continues to play that critical role in the future.

I thank you for the chance to testify here today, and I'm pleased, Mr. Chairman, to entertain any questions that you or the other members of your committee may have.

[The prepared statement of Mr. Brown follows:]

STATEMENT OF CLARENCE J. BROWN
DEPUTY SECRETARY, DEPARTMENT OF COMMERCE
TO THE SUBCOMMITTEE ON SCIENCE, RESEARCH & TECHNOLOGY
U.S. HOUSE OF REPRESENTATIVES

October 1, 1985

Mr. Chairman, Members of the Subcommittee:

I appreciate this chance to discuss the future role of the National Bureau of Standards. Today as never before, advances in science and technology are the key to the competitiveness of this Nation. It's estimated that the world's body of scientific knowledge doubles every decade. Ninety percent of all knowledge has come into existence since World War II. This proliferation of knowledge is constantly producing new technology. In general, technology is being produced so rapidly that it becomes obsolete within 5-7 years. In electronics it is 3-5 years. Some technology is obsolete before it's even off the drawing board. In fact, drawing boards, themselves, are becoming obsolete due to the advent of computer-aided-design.

With the coming of low-cost computer telecommunications networks, engineers, scientists and business people in every part of the globe have instant access to the latest technology and production techniques. Knowledge is replacing raw materials and labor as the primary source of wealth, thus allowing nations to create their own comparative advantage and overleap more highly-developed countries. In this way Japan has displaced America as the world's leading auto manufacturer; it has displaced Germany as the world's major camera maker; and it has displaced Switzerland as the world's premier watchmaker.

It is for these reasons that this Administration and the Department of Commerce in particular have given priority to

IMPROVING THE HEALTH OF THE U.S. SCIENTIFIC AND TECHNICAL ENTERPRISE. THE NATIONAL BUREAU OF STANDARDS FILLS A SPECIAL NICHE IN U.S. SCIENCE AND TECHNOLOGY. ITS WORK CONCENTRATES ON HELPING THIS COUNTRY IMPROVE PRODUCTIVITY AND QUALITY CONTROL BY USING NEW AND BETTER MEASURING TECHNIQUES AND STANDARDS. LIKE ALL ORGANIZATIONS, THE DEPARTMENT OF COMMERCE AND NBS SHOULD BE, AND ARE, LOOKING AHEAD AT WHAT IS IN STORE, WHAT THE COUNTRY'S MEASUREMENT NEEDS ARE, AND WHERE THE FEDERAL GOVERNMENT, THIS DEPARTMENT, AND NBS CAN PLAY A VITAL ROLE. YOUR HEARINGS ON THIS SUBJECT ARE TIMELY AND WELCOME TO THOSE OF US WHO ARE REVIEWING THE STATUS OF THIS IMPORTANT FEDERAL AGENCY.

WE ARE ALL CONCERNED WITH THE U.S. TRADE POSITION. WE HAVE NOT BEEN DOING WELL COMPETITIVELY IN A NUMBER OF PRODUCT AREAS. WE HAVE LOST, AT LEAST FOR NOW, SOME KEY MARKETS. BUT I WOULD LIKE TO SUGGEST THAT WE LOOK AT MORE THAN JUST THE NEGATIVES. THIS ECONOMY HAS SEEN MILLIONS OF JOBS CREATED, MANY MILLIONS MORE THAN HAVE BEEN LOST DUE TO OUR COMPETITORS' RELATIVE SUCCESSES. SINCE 1982, 8 MILLION NEW JOBS HAVE BEEN CREATED. IN 1984, WE WERE CREATING JOBS AT A RATE OF 300,000 A MONTH, WHICH IS MORE THAN THE EUROPEAN COMMON MARKET HAS CREATED IN THE PAST DECADE. BETWEEN 1950-1970, 75 PERCENT OF ALL NEW JOBS WERE CREATED EITHER BY BIG BUSINESS OR GOVERNMENT. BUT OVER THE PAST 4 YEARS, THE "FORTUNE 500" COMPANIES HAVE LOST OVER 2 MILLION JOBS, WHILE AT THE SAME TIME BUSINESSES LESS THAN 10-YEARS-OLD HAVE ADDED ALMOST 1 MILLION NEW JOBS.

SUCH A RECORD SUGGESTS THAT WE EXCEL LIKE NO OTHER NATION WHEN IT COMES TO HIGH TECHNOLOGY PRODUCT AREAS. THIS ADMINISTRATION UNDERSTANDS THE FRUSTRATION INVOLVED FOR THOSE WHO HAVE LOST JOBS DUE TO FOREIGN COMPETITION, AND WE ARE TAKING STRONGER STEPS TO ASSURE THAT AMERICAN PRODUCTS AND MANUFACTURERS ARE NOT DISCRIMINATED AGAINST. THE CLAMOR FOR PROTECTIONIST MEASURES FOR OUR INDUSTRIES HAS GOTTEN NOTICEABLY MORE VOCAL OF LATE. BUT

TRADE PROTECTIONISM IS NOT THE MAGIC ANSWER, BECAUSE OTHER COUNTRIES WILL INSTITUTE THEIR OWN PROTECTIVE MEASURES.

MOREOVER, PROTECTIONISM HAS THE INSIDIOUS EFFECT OF REDUCING OUR COMPETITIVE EFFORT FURTHER BY REDUCING PRESSURES TO EXERT EFFORTS TOWARD IMPROVING THE QUALITY AND PERFORMANCE OF OUR PRODUCTS AND PROCESSES THROUGH TECHNOLOGICAL ADVANCEMENTS. WE HAVE SEEN INSTANCES WHERE INDUSTRY SHOULD BE LOOKING AHEAD AND INVESTING IN RESEARCH AND DEVELOPMENT FOR THE FUTURE, BUT HAS BECOME DISTRACTED BY UNFAIR TRADE COMPETITION. IN THE LONG RUN, PROTECTIONIST MEASURES AS A SUBSTITUTE FOR TECHNOLOGICAL IMPROVEMENT HAVE ERODED THE STRONG, TECHNOLOGICAL FOUNDATION SO ESSENTIAL TO OUR ECONOMY.

TECHNOLOGY IS THE MOST IMPORTANT FACTOR IN DETERMINING THE INTERNATIONAL COMPETITIVE POSITION OF THE UNITED STATES TODAY. THE CONCLUSIONS OF THE PRESIDENT'S COMMISSION ON INDUSTRIAL COMPETITIVENESS CONFIRMED THE SERIOUSNESS OF THE DETERIORATING INTERNATIONAL COMPETITIVENESS OF U.S. FIRMS AND THE CRITICAL NATURE OF TECHNOLOGY IN RECOVERING OUR POSITION OF LEADERSHIP. TECHNOLOGY CONTRIBUTES TO NEW PRODUCTS, AND GIVES EXISTING PRODUCTS BETTER PERFORMANCE ATTRIBUTES SUCH AS HIGHER QUALITY AND RELIABILITY. IT ALSO LEADS TO LOWER PRODUCTION COSTS.

INDUSTRY CONCENTRATES ON TECHNOLOGY. IN FACT, MORE THAN 50 PERCENT OF THE R&D UNDERTAKEN IN AMERICA IS FUNDED BY PRIVATE INDUSTRY--SOME $53 BILLION IN 1985 AS COMPARED WITH ROUGHLY $50 BILLION SPENT BY GOVERNMENT ON R&D. HOWEVER, UNDERLYING ALL TECHNOLOGY IS A BASE OF SCIENCE, THE SUM OF ALL SCIENTIFIC AND TECHNICAL KNOWLEDGE. AND THAT'S WHERE THE FEDERAL GOVERNMENT HAS AN ESSENTIAL ROLE, SUPPORTING FUNDAMENTAL RESEARCH IN SCIENCE AND ENGINEERING. THE PRIVATE SECTOR SIMPLY LACKS SUFFICIENT INCENTIVES TO BROADLY SUPPORT BASIC RESEARCH THAT IS FAR FROM THE MARKETPLACE. WHEN THE GOVERNMENT SUPPORTS THIS RESEARCH, THE RESULTS RESIDE IN THE PUBLIC DOMAIN, AVAILABLE FOR ALL TO USE.

Another public domain component of technology is so-called "infratechnology". This is the organized body of scientific and engineering knowledge for enhancing scientific research and technology-based economic activity. The National Bureau of Standards is the major source of infratechnology in the form of tables of reliable data, predictive equations and models, and well-documented measurement methods, techniques and standards.

Let me put into context the importance of measurements to those industries where the application of advanced technologies is producing high rates of growth. In 1983 across the whole of the U.S. economy, $163 billion was spent on measurements, or 3.5 percent of the nation's GNP. Nearly one-half of that total was concentrated in 20 sectors of the economy, including electronic components where measurements account for 20 percent of that industry's labor costs. NBS plays the central role in developing the basis for all these measurements. The U.S. needs these measurements for new product development, efficiency and quality assurance in manufacturing and equity in trade.

America faces the task of maintaining the strength of our technology base and focusing its use for the maximum benefit of domestic industry at a time of mounting Federal expenditures. One solution is to increase private industry involvement in the development of technology components. NBS has an extremely strong industry involvement, and Dr. Ernest Ambler, the NBS Director, will address that in more detail in his testimony.

Making Federal research facilities available also can provide important advantages to U.S. companies without increasing the burden on federal finances. I refer to those facilities that would be too expensive or impossible for a private firm to duplicate. This could be either for cooperative research or for the development of proprietary data. While most of the cooperative work at NBS results in data that will reside in the public domain, last year NBS started to allow the use of its special facilities for proprietary research by U.S. firms. Several U.S. firms --large and small-- already have made use of the NBS nuclear research reactor, large scale environmental test chamber, and combustion calorimeter. Looking toward the future, I think this is a healthy trend for NBS and other federal facilities.

The results of cooperation on R&D are yielding some positive results in other areas, results that have both short- and long-term payoffs. The recent changes in antitrust laws have permitted joint R&D by companies that would have been unthinkable just a few years ago. Now, under certain conditions, companies can pool their knowledge and resources free of anti-trust challenges.

Funding and New Programs

The Department of Commerce, like the rest of the Federal Government, has had to make some difficult choices over the past several years. We have to keep Federal spending down. Recognizing the importance of NBS to our economy, we have made every effort to provide this agency with the resources necessary to do the measurement research and standards work industry sorely needs. In fact, as Chart 1 shows, NBS has fared well when compared to the Department of Commerce as a whole. While the rest of the Department has seen reductions of 18 percent, we have been able to keep the Bureau's funding just about even during the two budget years I have been in Commerce.

There is another comparison that merits this Subcommittee's attention. My second chart lists the new initiatives contained in the last two NBS budgets submitted to Congress. The final appropriation in FY 1985 and the FY 1986 House allowance both funded only about forty percent of the dollars requested by the Administration for new NBS programs.

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Conflicting Demands

The last comparison I'll make illustrates one difficulty NBS faces in planning future programs. Some people say NBS should be a standards laboratory in a narrow sense and respond to particular needs of industry as problems arise. Others say that NBS should be a broad and future-oriented lab and address the measurement-related problems it sees U.S. industry facing ahead as it works to improve U.S. competitiveness. I think the latter mission is far preferable for a technological nation competing in a global economy.

Primary standards like mass, voltage, or length are important but relatively straightforward. The continuing needs are mainly to increase the accuracy of measurement methods; scientists know the approaches to follow. An emerging technology like fiber optic communications, however, is developing with rapid changes in technology. In this case NBS has been asked by industry to help bring order to the market of buyers and sellers by forging a consensus on standard methods of measuring fiber optic attenuation, power, and other technical parameters. As the next generation technology becomes apparent, NBS is continuing such efforts in single mode fiber and integrated lightwave optoelectronics. There is always an increasing demand for new measurement information. This presents a true dilemma for those of us making decisions about the future for NBS. Science and technology still demand maintenance and improvement of mass, voltage, length and other traditional measurement standards, even while NBS has to undertake research efforts in the emerging technologies.

Management Issues

As is the case in managing a business or any other organization, in managing scientific laboratories like NBS, I naturally come across some issues on which managers may disagree.

One issue concerns the timing for major efforts in support of particular new technologies. Since the diffusion of innovations into successful commercial trade usually follows long and uncertain paths, at any one time there are many technologies or products seeking research or standards support. The difficult decision is determining where and when the lack of such support will be a significant barrier to commercial progress. For example, fiber optic technology has been with us for a dozen or more years, but only in the last few years have conditions been appropriate for widespread use in telecommunication systems, and

Only recently have industry's needs for measurements and standards become focused. Had the government made a big research investment beforehand, we might have wasted both time and money. In the same respect, if we try to develop standards, even voluntary standards, too soon, we run the risk of retarding innovation in an emerging technology. But if we wait too long to do the measurement research and standards work, we run the risk of missing out on production efficiencies and losing our share in the marketplace.

Another difficult issue involves setting priorities for allocating limited resources. As this Subcommittee undoubtedly has concluded, even informed scientists and managers are likely to differ in their priorities. For example, my third chart shows the variation in ranking of NBS initiatives during the FY 87 budget process by members of the NBS Visiting Committee and by NBS. While there is a consensus at the highest and lowest rankings, different criteria and perceptions result in varying priorities that must be resolved during the budget process.

Because of the Federal deficit, the total budget in the near term for NBS must remain stable. That means it is necessary to eliminate some programs in order to undertake research in new problem areas. This is the background for the requested termination of the fire and building research programs proposed in recent NBS budgets. While these programs have been carrying out good research and providing useful services, the technology is not changing as rapidly as it is in many other fields. Nor are these areas subject to intense foreign competition. Moreover, there are areas where the private sector should be doing more with its own financing.

The proposed reduction of the NBS program in domestic computer standards is based upon the belief that the U.S. computer industry is vigorous enough to pursue these areas itself, and to do so with

PRIVATE FINANCING. AS DIFFICULT A PROCESS AS THIS IS FOR NBS AND AS DIFFICULT AS IT IS TO GET AFFECTED USER GROUPS TO SHOULDER A BURDEN RATHER THAN ACCEPT TAXPAYER LARGESSE, IT IS NECESSARY IF LIMITED PUBLIC RESOURCES ARE TO BE AVAILABLE TO SUPPORT NEW AND FASTER-MOVING TECHNOLOGICAL AREAS.

AS YOUR LETTER OF INVITATION POINTED OUT, NBS MUST DO RESEARCH NOW IN ORDER TO SUPPORT INDUSTRY EFFORTS TO BE COMPETITIVE OVER THE NEXT 15 YEARS. LET ME MENTION SEVERAL OF THESE FUTURE OPPORTUNITIES FOR INDUSTRY I SEE DEVELOPING DURING THE NEXT DECADE.

LIGHTWEIGHT, HIGH-PERFORMANCE COMPOSITE MATERIALS WILL ALLOW COMMERCIAL AND MILITARY AIRCRAFT THAT CONSUME LESS FUEL AND USE LESS CRITICAL MATERIALS SUCH AS TITANIUM.

INTEGRATED OPTICAL ELECTRONICS WILL ALLOW HIGHER PERFORMANCE COMMUNICATION AND COMPUTER SYSTEMS AT LOWER COST.

DEVELOPING A COLD NEUTRON RESEARCH FACILITY WILL PROVIDE AN OUTSTANDING RESEARCH TOOL FOR U.S. SCIENTISTS IN MATERIALS SCIENCE, SUCH AS CERAMICS, COMPOSITES AND POLYMERS, AND FOR USES IN COMMUNICATIONS, ELECTRONICS, MEDICINE, AND OTHER FIELDS.

BIOTECHNOLOGY PROCESSING TECHNIQUES WILL PROVIDE MANY OPPORTUNITIES FOR NEW PRODUCTS AND MORE PRODUCTIVE BIOCHEMICAL MANUFACTURING PROCESSES WITH HEALTH AND AGRICULTURAL APPLICATIONS, AS WELL AS INDUSTRIAL USES.

EFFECTIVE NETWORK CONNECTION METHODS FOR ADVANCED INFORMATION SYSTEMS IN MANUFACTURING AND TELECOMMUNICATIONS WILL LEAD TO COMMERCIAL OPPORTUNITIES FOR U.S. FIRMS.

ADVANCED CERAMIC MATERIALS WILL LEAD TO LIGHTER AUTOMOTIVE ENGINES WITH HIGHER OPERATING TEMPERATURES AND FAR GREATER FUEL EFFICIENCY. WITH YOUR PERMISSION, I WOULD LIKE TO SHOW YOU NOW A brief videotape that explains industry's need for NBS' support in this area.

(Show 4-minute videotape on NBS advanced ceramics work.)

Staffing Issues

Once we make those hard decisions to move ahead with certain areas for NBS, the Bureau must have not only the financial resources, but also the pool of talent needed to get the job done. The experience at NBS for the past year is instructive. Bureau managers have found the market for electronics engineers and computer specialists extremely competitive, with top-notch researchers hard to come by. It has been relatively easier to recruit chemists and physicists. NBS also has had considerable success in bringing in materials scientists and engineers, especially in the area of ceramics where there is only a small source of talent to draw from. Even in the most competitive fields, we know that some of the best and brightest researchers are attracted to NBS because it has the reputation as a superior research institution that specializes in technical excellence. The net combination of aging, turnover, and numerous management actions is that since 1980 the average age of NBS employees has declined slightly, with the most recent calculation being approximately 42 years.

In fact, the Visiting Committee for NBS that advises the Secretary of Commerce has taken note of the Bureau's personnel situation in recent reports to Secretary Baldrige. Where three years ago this group of outside advisors was warning that the Bureau staff was spread very thinly and needed stability, in the most recent report to the Secretary, the Visiting Committee said that mangement and staff at NBS were strong. Their general assessment was that "The National Bureau of Standards is in good shape. The quality of the

SCIENCE AND ENGINEERING IS HIGH, MORALE IS GOOD AND THE EQUIPMENT IS ADEQUATE."

I TAKE AS AN INDICATOR OF THE BUREAU'S PERSONNEL SITUATION THE STAFF'S CONTINUED RECOGNITION BY OTHERS. FOR INSTANCE, JUST LAST WEEK NBS RESEARCHERS RECEIVED EIGHT OF THE 100 AWARDS GIVEN ANNUALLY BY RESEARCH AND DEVELOPMENT MAGAZINE TO HONOR THE MOST SIGNIFICANT NEW TECHNICAL PRODUCTS OF THE PRECEDING YEAR. THIS WAS THE MOST AWARDS GIVEN TO ANY COMPETITOR, INCLUDING SOME OF THE TOP COMPANIES AND INSTITUTIONS IN THE UNITED STATES AS WELL AS JAPAN. I HAVE ATTACHED TO MY STATEMENT FOR INCLUSION IN THE RECORD A LETTER FROM PRESIDENT REAGAN TO NBS DIRECTOR AMBLER CONGRATULATING THE BUREAU ON THIS RECOGNITION. I SHOULD ALSO MENTION TWO OTHER TOP AWARDS WON BY NBS STAFF. DR. JOHANNA SENGERS, A PHYSICIST AT NBS, RECEIVED THE TOP 1985 AWARD FROM WOMEN IN SCIENCE AND ENGINEERING (WISE), AND MR. JUDSON FRENCH, DIRECTOR OF THE NBS CENTER FOR ELECTRONICS AND ELECTRICAL ENGINEERING, RECEIVED THE PRESIDENTIAL DISTINGUISHED RANK AWARD, THE HIGHEST AWARD IN THE FEDERAL CIVIL SERVICE. THESE AWARDS ARE ONLY A SMALL NUMBER OF ABOUT EIGHTY RECEIVED BY NBS STAFF FROM OUTSIDE PROFESSIONAL ORGANIZATIONS LAST YEAR.

NBS HAS A SPECIAL MISSION AS THE ONLY FEDERAL AGENCY CHARGED WITH DIRECTLY SERVING U.S. INDUSTRY. IT IS DOING A FINE JOB AND HELPING THIS COUNTRY TO BE MORE COMPETITIVE BY ADVANCING MEASUREMENT SCIENCE AND TECHNOLOGY AND PROVIDING CRITICAL SERVICES. I INTEND TO DO EVERYTHING I CAN TO MAKE SURE IT CONTINUES TO PLAY THAT CRITICAL ROLE IN THE FUTURE.

THANK YOU FOR THE CHANCE TO TESTIFY HERE TODAY. I WILL BE PLEASED TO ENTERTAIN ANY QUESTIONS YOU MIGHT HAVE.

CHART 1

COMPARISON OF DOC BUDGET CHANGES 1984-86

	FY 84 APPROPRIATION (MILLION)	FY 86 REQUEST (MILLION)	PERCENT CHANGE
NBS	$121	$120	-1%
REST OF DOC	$1,873	$1,541	-18%

CHART 2

NBS BUDGET INITIATIVES FOR FY 1985/1986
(IN MILLIONS OF DOLLARS)

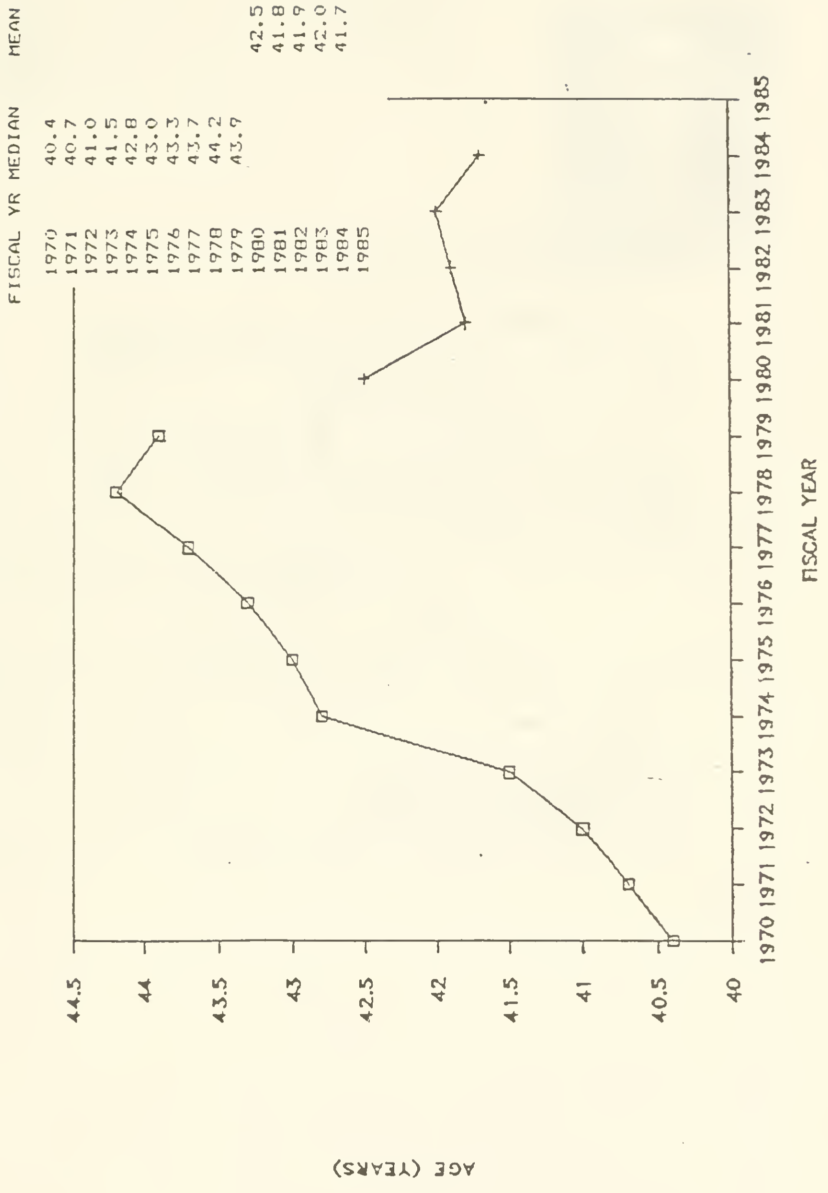
85 BUDGET REQUEST		CONGRESSIONAL APPROPRIATION
PROCESS AND QUALITY CONTROL	2.500	0.556
BIOTECHNOLOGY	3.000	0
COLD NEUTRON SOURCE	1.500	1.500
	7.000	2.056

86 BUDGET REQUEST		HOUSE ALLOWANCE
PROCESS AND QUALITY CONTROL	1.944	1.944
BIOTECHNOLOGY	3.000	1.555
ADVANCED CERAMICS	3.500	3.000
COLD NEUTRON FACILITY	8.000	0
	16.444	6.499

CHART 3

PRIORITY OF 1987 INITIATIVES

		VISITING COMMITTEE				
	NBS	A	B	C	D	CUM.
COLD NEUTRON RESEARCH FACILITY ($8.0M)	1	1	1	2	1	1
FIBER-OPTICS ($10.0M)	2	2	3	10	8	5 (TIE)
PROCESS & QUALITY CONTROL ($6.1M)	3	3	4	3	3	2
BIOPROCESS ENGINEERING ($5.8M)	4	8	5	6	4	5 (TIE)
ADVANCED COMPUTER CONCEPTS ($8.0M)	5	4	8	8	9	8
FACILITIES AGING ($4.5M)	6	10	10	9	10	10 (TIE)
ENGINEERING DATABASES ($6.1M)	7	7	7	5	2	4
TECHNOLOGY TRANSFER ($0.5M)	8	11	11	11	6	10 (TIE)
SCIENTIFIC COMPUTING SUPPORT ($2.1M)	9	9	9	4	11	9
MICROWAVE METROLOGY ($6.3M)	10	6	2	1	7	3
HIGH-PERFORMANCE COMPOSITES ($7.7M)	11	5	6	7	5	5 (TIE)



FISCAL YR	MEDIAN	MEAN
1970	40.4	
1971	40.7	
1972	41.0	
1973	41.5	
1974	42.8	
1975	43.0	
1976	43.3	
1977	43.7	
1978	44.2	
1979	43.9	
1980		42.5
1981		41.8
1982		41.9
1983		42.0
1984		41.7
1985		

THE WHITE HOUSE
WASHINGTON

July 12, 1985

Dear Dr. Ambler:

Congratulations to you and your associates at the National Bureau of Standards for the recent recognition given by Research & Development Magazine.

In designating what it considers the "100 most-significant technical products of the year" developed by our Nation's laboratories, the publication singled out seven products from the National Bureau of Standards. No other company or government agency had as many.

Almost a century ago Congress created the National Bureau of Standards to strengthen, advance, and assure effective application of the Nation's science and technology. The Bureau is living up to its mandate in a way that brings pride to everyone concerned.

Sincerely,

Ronald Reagan

Dr. Ernest Ambler
Director
National Bureau of Standards
Department of Commerce
A1134 Administration Building
Gaithersburg, Maryland 20899

DEPARTMENT OF COMMERCE UNITED STATES OF AMERICA

BIOGRAPHY
CLARENCE J. BROWN
DEPUTY SECRETARY OF COMMERCE

Clarence J. Brown has served as Deputy Secretary of Commerce since July 6, 1983. From 1965 until 1983, Mr. Brown was a member of the U.S. House of Representatives from the 7th District of Ohio. He served on the Joint Economic Committee from 1969-1983 (ranking Republican from 1975-1983); Energy and Commerce Committee in 1967-1983 (ranking Republican on Energy Subcommittee from 1975-1983); and Government Operations Committee from 1966-1983 (ranking Republican on Intergovernmental Relations Subcommittee from 1969-1983).

In 1982, Mr. Brown was the Republican candidate for Governor of Ohio.

Mr. Brown was editor and publisher of several Ohio newspapers from 1949 until 1965 when he became president and chairman of the board of the Brown Publishing Company. Since 1978, he has served on the Advisory Board of the Georgetown University Center for Strategic and International Studies and the Advisory Council of the American Enterprise Institute Study of Government Regulation.

He served in the U.S. Navy from 1944-46 as an enlisted man, received his commission in the Naval reserve in 1947, and served on sea duty during the Korean conflict from 1950-52.

Mr. Brown was born June 18, 1927, in Columbus, Ohio. He received a Bachelor of Arts in Economics from Duke University in 1947 and graduated with a Master's degree in Business Administration from Harvard University in 1949. He holds an honorary degree from Miami (Ohio) University. He is married to the former Joyce Eldrige. They have three children, Clancy (1959), Cathy (1965) and Roy (1967).

March 1985

Mr. WALGREN. Thank you very much, Mr. Secretary. Some would say that the best comparison of how NBS has fared these past several years, in terms of budget weight with the administration, would be not so much a comparison of what has happened with other Department of Commerce programs, which tend to be in that discretionary domestic area that has really been substantially reduced, but with other science, pure science-related efforts.

And I understand that, aside from the Department of Energy, where there's been a controversial cutback in the Government's role on research—and aside from one other area, NOAA, which has received not what you call enthusiastic support, other agencies' science budgets are up.

Mr. BROWN. Well, I must say I won't—I have to differ a little with that because I also prepare the budget for NOAA.

Mr. WALGREN. Well, then perhaps it received it from your level, but not other levels. But the point is that the National Science Foundation, which this committee also oversees, has received something in the range of a 50-percent increase in its budget even during these years. And other agency budgets in the science area area are substantially up. The National Science Foundation is even publicly planning large increases, somewhere in the range of 40 percent per year, for several years running.

And yet, publicly we're saying well, we have this Federal budget deficit and that means that anything we do has got to mean we stop doing something else. And the impact of stopping doing something else in this year's submission was stopping 25 percent of the Bureau's present functions.

If we were to pick up the initiatives that the administration recommended, it's my understanding that we would have had, in order to live within the budget levels that the administration recommended, we would have had to stop 25 percent of what was currently happening at the Bureau.

Mr. BROWN. I'm not sure I know where you're getting the 25 percent, Mr. Chairman.

Mr. WALGREN. Well, and I can't do the numbers with you because I'm not that familiar with them, but I think somebody probably can. But let's just say that you would have had to accept the administration's budget for NBS this year, in doing initiatives that the administration felt was important to pick up, we would have had to stop doing a tremendous amount of current functions——

Mr. BROWN. Well, if I may be specific, there was a reduction proposed in fire and building expenditures and ICST. And our ambition was as Mr. Brown on your committee suggested, that some of that might be picked up by the private sector. There has been an increase. Let me give you the budget figures for 1981 and 1985 of the National Bureau of Standards.

With reference to appropriation, the budget has gone from $102 to $124 million. The contribution from the private sector to the activities of the National Bureau of Standards has gone from $28 to $58.5 million. And the contribution from other Government agencies to the activities of the National Bureau of Standards has gone from $52 to $68 million. That in effect means from 1981 to 1985, the expenditures have gone from $182 million in total to $250.5 million in total. That is a significant increase in expenditures. It isn't quite as high as the National Science Foundation, which is a basic research activity, nor is it as high—and I would make no representations that it's even close—to what's been expended by the Defense Department in research and technology and development. But then, unfortunately, we don't have the budget the Defense Department has by many microcosms.

Mr. WALGREN. Well, as I understand, certainly the private contribution and the contributions from other Government agencies, which would not be in these numbers, certainly makes sense to take that into account.

Mr. BROWN. Those are solicited actively by the Bureau of Standards and by the Department. And as a matter of fact, I've spent some of my time in preparing the budget this year and negotiating with some other Federal agencies, their appropriate support for Bureau of Standards' activities with their budget contribution.

Mr. WALGREN. Yet the budget that was submitted by the administration would total in recommended reductions, under both the overall reductions proposed under the category of the President's deficit reduction program, and the program decreases. If you take those two together, you would total in recommended reductions about $24 million in previous Bureau of Standards appropriation.

Mr. BROWN. Current appropriation.

Mr. WALGREN. Yes.

Mr. BROWN. Because those appropriations have continued, nonetheless the administration has recommended that they be reduced or terminated in favor of other work in more advancing technologies.

It is, as I understand—and has been discussed with the previous witness—a difference of opinion on not the importance of the work that has been done and is currently being done and currently being done very effectively, I think, by the Bureau of Standards, but whether or not those should be financed by the Federal appropriations. And the administration has proposed to the Congress that some of these activities be yielded up to the private sector or—we encourage private sector support for them—and those funds devoted to new and emerging technologies.

The success in doing that will be limited as long as the Congress is willing to provide the funds. Because it's been my experience, both in the Congress and in the administration, that where the Federal Government will provide funds, the private sector does not rush in and elbow them out of the way.

Mr. WALGREN. Well, two-thirds of the reductions were in program decreases. One-third was in an overall squeeze. The kind of things like a 5-percent pay cut and the program freezes with respect to inflation, and take all the administrative cost reductions, things like that, which were just——

Mr. BROWN. Those were Governmentwide, as you know, and certainly Departmentwide, at least. And also the Cost Reduction Act approved by the Congress required us to reduce certain functions within the Department and agencies of the Government such as travel, public relations, and——

Mr. WALGREN. Well, I guess my point though is that in order to——

Mr. BROWN. It was essentially ordered. I mean, that's the point I was making, in some instances.

Mr. WALGREN. But even though the administration did support these specific initiatives, which were the new programs, and the Congress struck a balance between those, the degree of support for those new programs and continuing some of the older funding. In order to support those programs to the degree to which you felt that they should be supported, you required substantial stopping of work that was previously going on.

Mr. BROWN. In three programs.

Mr. WALGREN. Admittedly, two-thirds of which would have been in the area of the building research and computer science and the fire. So, two-thirds of the reductions were explained by the disagreement between the executive and the Congress about whether or not these functions should continue to be carried out in this——

Mr. BROWN. Not whether or not they should continue, Mr. Chairman, but whether or not they should be funded by appropriations. Our ambition has always been that these programs be picked up by the private sector or by some other agency in some other way than the function that we see is the major responsibility of the Bureau of Standards, which is to serve industry with reference to technologies, particularly developing technologies.

Mr. WALGREN. Yes. But aren't you still in the position, though, of essentially advocating a no increase in effort in this area even though we know there's a lot to be done that would contribute very beneficially in this area?

Mr. BROWN. In which area, Mr. Chairman?

Mr. WALGREN. In the overall area that the Bureau can make a contribution. Now, you say on the one hand that you can stop some programs, and we had our disputes about that, and they were not stopped and certain things were not pursued and certain things were only partially pursued to none of our satisfaction, because this committee wanted to pursue all of those initiatives that the administration wanted to pursue, and in fact sent to the floor a bill which did just that, but found the administration not in support of that bill because of the disagreements——

Mr. BROWN. You're beginning to confuse me, Mr. Chairman. I am under the impression that the bill that went forward did not include all of the new initiatives that the Congress was asked for. And certainly what passed the Congress did not include all of the initiatives that we asked for.

The difference of opinion is not—again I want to point out—is not that we don't see merit in fire and building technology. We do. And we certainly have when the Congress has appropriated the funds for us to continue the program, or in fact on occasion expand it. The Bureau has undertaken that aggressively.

We are currently the authority and the funding source for some others who do work in this field and those two fields and in the computer science and technology area. The difference is whether or not, at a time when funds are short because we're trying to—the Congress and the administration hold back the growth of the Federal deficit—whether or not we can see some programs now being undertaken by the Bureau of Standards which we think are not specifically related to the commission of the Bureau, which is to serve standards in industrial development, whether or not those programs might not be absorbed by the private sector or some other element, and let us use some of that money to go into new and developing technologies which we think in the long run will improve the economy of the country.

Right now we have three people from the National Bureau of Standards in Mexico City because of the special knowledge we have in the Bureau in building technology. So, we are looked upon not only as a national authority, but a worldwide authority in the field of building technology.

The only question that we have is whether or not those funds that are now being expended in that way might be expended by the Bureau more effectively, for the benefit of the country, in other new technology areas, and let the expertise that we have developed thus far in fire and building technology be picked up by some other element.

Mr. WALGREN. Well, I suppose one of the differences here is that without the assurance that it will be picked up by some other element, the Congress was unwilling—as Mr. Brown said earlier—Mr. Brown being the representative from California—that Congress was unwilling to take that leap.

Mr. BROWN. It puts us in a catch-22, I might say. If we could agree between the Congress, the administration, and either another source from within the Government or private industry, that somebody else would pick it up, then we could take care of the problem that way.

Mr. WALGREN. It was hard for me to understand what transpired in this last legislative go around with the Bureau, because even though no Member of Congress was willing to take the administration's position to wipe out the fire and the building effort, at least not formally, in the administration's proposals that were offered on the floor, there were the most shirttail numbers cuts made in the heat of the offering of amendment process on the floor that almost, given the political climate that prevailed in the House of Representatives—where people were saying oh, we're going to do all these things, and the money will be there, and yet, none of us who were relatively familiar with the budgets knew where the money could come from.

And one fear was that people were operating under real misassumptions of what residual moneys were in the Bureau, whether there were pools of money that could be drawn in to feed these functions, that even those wanting to live within these lower numbers, and yet do all these things, wanted to feed, it was our impression that they were creating that pool of money out of whole cloth on the floor. It was a very chaotic legislative process, and one that in my view very much endangered what might have been the product of the House of Representatives.

And in that sense, it can only be viewed with great apprehension.

Mr. BROWN. Well, let me speak to both the effort to get back into the appropriations process those new initiatives that I had recommended and the Office of Management and Budget had supported in the proposal to the Congress.

We didn't want to lose the cold neutron reactor. The Japanese and the French are both in the process of building and developing a cold neutron reactor for precisely the reasons I mentioned in my testimony, the availability of a reactor for research in ceramics and some other activities. And we thought that a delay in getting that reactor up and running and available to American industry might be harmful to our technological competitiveness in a number of fields.

With reference to budget process, it's been my experience in two years of what I consider to be one of the more sophisticated departments—sophisticated because it is small and business oriented—with reference to our ability to keep track of the expenditure of the Federal dollars. It is very difficult to find out from one year to the next, in any specific bureau, what the carryover funding is.

We felt that we had carryover funding sufficient to meet the needs of the new technologies that the Congress had indicated it wasn't going to fund, and that we would like to have the authorization for those to be expended if we could come up with the funds, and we felt we could.

Mr. Walgren. In retrospect, were those funds there in the carryover?

Mr. Brown. We think we have carryover funds in most of our agencies, that as I suggested, are hard to identify. Because unlike a private business—and I'm still involved in a private business in my private life—I can get a monthly balance sheet of what we have in the way of cash on hand. Such balance sheets don't exist in Federal agencies.

Mr. Walgren. Let me ask one other question that's going back to what we were talking about before, about the general approach that you have to stop doing something in order to do anything new, and the fact that other science contributing agencies are not suffering under that kind of restraint.

Admittedly we have greater access to some private funding in the Bureau of Standards area than do some of the other science agencies. And as you say, you can put a dollar figure on that. But——

Mr. Brown. Well, 70 percent of the science agencies, I guess, and the Defense Department don't have that kind of access. They don't go to the private sector, I guess, for supportive funding. It works the other way, I guess.

Mr. Walgren. Yes. But even given that, you identified what, about a $25 million increase in private funding? I'm sorry, I can't remember.

Mr. Brown. The figures I have are that in 1981 the budgetary figures were $102 million from the Federal appropriations; $28 million from private contributions, and $52 million from other Government agencies. In 1985 the figures were $124 million from the Federal appropriations, $58.5 million from private contributions, up from $28 million, and $68 million from Federal agencies, up from $52 million.

Mr. Walgren. OK. Well, it seems to me—or one view could set aside the contribution from other Federal agencies in that they must have some purpose in the work that they're doing.

Mr. **Brown**. All of them have purpose in the work they're doing. They have to be solicited. We are having, for instance, a substantial increase in the funds available for metrology, we think next year, that come from the Defense Department. And those have been negotiated with the Defense Department. We make an effort to——

Mr. **Walgren**. Well, we're still left with if you focus on the private increase, $25 million or thereabouts over 4 years. And the question would be, are we planning to appreciate the National Bureau of Standards in the same way that we are appreciating other Government science agencies, even given the $25 million or whatever percentage add on, we could reasonably anticipate bringing in from the private sector?

I think clearly that's money that is spent in this effort and can be measured as an increase in their effort. At the same time, it is the strongest of signals that more work truthfully is probably called for because the private sector is saying, in a sense, gee, you're not doing certain things that we know we need to do so much that we're even willing to put our money into it at that point. And usually that's not volunteered from the private sector.

So, my question is, given what's happening in other Government science agencies, given some accounting for the private sector increase that we hope we can bring in, are you able to plan for increases in the National Bureau of Standards as is being planned for other agencies that are making an even more tangential contribution to the nuts and bolts of commercial scientific advancement?

Mr. **Brown**. We are doing so, Mr. Chairman. That figure goes up in total from $182 million in 1981 to $250.5 million. The private sector contribution increased $30.5 million, and we obtained another $16 million over that period from Government——

Mr. **Walgren**. But now where do we go from where we are now?

Mr. **Brown**. The increase, if I may, in the Federal appropriation was $22 million. Where do we go in the future?

Mr. **Walgren**. Yes.

Mr. **Brown**. Well, we are in the process, Mr. Chairman, of looking at our future as we do on a fairly regular basis with a long range plan for the Bureau of Standards. This copy that I have is one that came out, I think, in 1981, and one is in preparation and should be out within the next month or two from the Bureau of Standards on their concepts of where they're headed.

Where the budget will go is difficult for me to predict because I don't know what constraints will be put on the Department and on me in preparing the budget by the Office of Management and Budget and the Congress itself. We will continue to strive to move the Department into the new high technology areas as we did with the budget presentation that we made last year, and which we fought for right up until the appropriation process was completed.

Mr. **Walgren**. Do we have those projections for the record of the longer range plan?

Mr. **Brown**. No. I said these are long range plans in substance of the activities of the Bureau of Standards, and they will be completed within the next month or two for the update that follows this 1981–82 version that I show you here.

Mr. WALGREN. Well, my own wish, of course, is that we would be seeing those responsible for the Bureau of Standards making the same kind of concrete planning for the relatively near-term outyears that is going on in other science agencies.

Mr. BROWN. That's precisely what this is.

Mr. WALGREN. All right. The Chair would recognize Mr. Brown.

Mr. BROWN of California. Thank you. I don't think this committee ought to badger our distinguished former colleague over some of these items, because in looking at the budget presentations for last year, as it moved through the process from the Bureau to the Department to OMB, I think he was probably on our side on most of these issues. And unfortunately he's in the position of having to defend the OMB numbers, which I think are indefensible, but he does a very good job of doing that.

I would just like to suggest that in view of the great success you've had in soliciting private contributions to support essential programs at the Bureau, that it might be wise, in order to resolve this problem, if we were to use a little imagination, as I suggested to Dr. McTague, in trying to find an extra $5 or $10 million to support the fire and building programs instead of just cutting them off at the pockets. The Department didn't do that with the Landsat Program, for example, which was recognized as being a potentially very valuable program.

I would take a little issue with what you said about fire and building as not being programs which are rapidly evolving. The fact of the Mexico City earthquake, for example, which illustrates needs in both the area of fire and building technology, it seems to me to indicate that there are huge public benefits from continuing to facilitate rapid evolution in these areas.

The problem mainly is in the nature of the industry which is being served here. The building industry is not, per se, capable of mobilizing a national commitment to support this kind of research. We made, I think somewhere, determinations in connection with aeronautics research, which the administration studied at great length and decided that it was essential to continue with a very strong Federal role.

Now, there's no reason why we should butt heads against each other on something that we all recognize is valuable, when what we really need is a little ingenuity in devising the best way to continue these programs more than anything else.

Mr. BROWN. I agree with you thoroughly, Mr. Brown. If the committee can advise us of a process by which we can get financial assistance out of the building industry and out of the insurance industry and the others that are affected we'd be delighted.

The building industry, as you pointed out, is evolving. We've moved a prestressed concrete and a lot of other building methods. Certainly I don't want to have anything in my testimony or my response to questions to indicate that we see no value in fire and building research. We see great value in it, both from the standpoint of saving lives and costs in such situations as the earthquake in Mexico and earthquakes anyplace else.

The problem is with limited funds, whether that is an expenditure that the National Bureau of Standards, with its charge, should be undertaking by comparison, say, to fiber optics or ceramics or some of the other industrial technologies. And that's our problem.

Mr. Brown of California. Well, Mr. Secretary, you know better than I that the fiber optics and ceramics research caters to the needs of a large segment of American industry which is fully capable of supporting that research if they wished to do so. Just as the steel and automobile industries could have supported research in automated manufacturing if they had chosen to do so.

We need leadership from the Federal Government, that is what we need.

Mr. Brown. Our research, again in those areas, is designed for standards——

Mr. Brown of California. So is our fire and building research designed for standards so that it will make this country safer. That's a semantic evasion, Mr. Secretary. I'm not criticizing you for engaging in it, but I think it is. I don't want to be bitter, but the Executive Office has shown great ingenuity in arranging private financing for a war in Nicaragua. You can't tell me that similar ingenuity couldn't support private financing for something vital to the future of this country.

Mr. Brown. We'd be delighted to have that ingenuity, and we'd be glad to have the help of the committee in devising it.

Mr. Brown of California. I have no further questions.

Mr. Walgren. Thank you, Mr. Brown. Mr. Ritter?

Mr. Ritter. Thank you, Mr. Chairman. It's always a pleasure to have a former colleague come testify before us as an individual wearing the hat of a member of the executive branch. I might just allude to my colleague from California and his comments on the war in Nicaragua. He is one of our great experts on that war. We have recently traveled to the region and have met with all of the major figures in the region. I'm wondering whether he can advise you on some of the innovations that have taken place in funding that war so that you can fund the fire and building construction research programs.

Mr. Brown. Fortunately the war in Nicaragua does not come under the jurisdiction of the Commerce Department, Mr. Ritter.

Mr. Ritter. Fortunately. Talking about the jurisdiction of the Department of Commerce and the National Bureau of Standards' laboratories, if you look upon the growth of certain science budgets in the Federal Government, if you look upon the future of Federal involvement in underpinning industrial competitiveness, if you look at what the major competitor nations are doing in terms of their own public interventions in the funding and targeting of crucial industries, crucial areas of industrial research, then you come back to our own machinations to review the role and the function of our Federal and national laboratories. You come up with the idea that, well, the Bureau of Standards is probably further along in achieving some of this Federal private sector cooperation, generating of private sector support seeking to underpin America's industrial competitiveness, than some others. So, shouldn't the National Bureau of Standards be treated more like a potential treasure trove of cooperative effort underpinning industrial competitiveness? Shouldn't we take the Bureau of Standards out from its kind of weak sister relationship in the Department of Commerce and either within the Department of Commerce or outside of the Department of Commerce give some greater muscle to this organization of research development and technology development so as to promote the industrial competitiveness theme?

That's both a statement and a question, but I'd like to just have your response.

Mr. Brown. Well, if I may, and I'm not here to testify as an authority on all the other scientific research being undertaken by the Federal Government. None of that is under my jurisdiction.

If I recall the figures, Mr. McTague said that 70 percent of that was in the defense arena. And as we all know, there has been a sharp increase in expenditures in the entire budget of the Defense Department. I would assume that there has been a similar increase in defense research that's not exactly all oriented to business technology and it is not something in which we have been involved.

Among the other areas that do major research, I would assume both NIH and NASA, with their rather specialized interest in health and in outer space technology, are substantially part of that. And while there are certain things that can translate into business and trade relationships, certainly health is an industry and we do a lot of work in terms of trade with health facilities in this country. And certainly NASA has contributed.

Our specific responsibility is standards for industrial development. The National Science Foundation, as I understand, has its major responsibility in grants for pure research being done by a wide variety of nongovernmental activities and agencies outside the Federal Government, and it is—again I would emphasize—in pure research.

Our responsibility is not in pure research to the degree that it is pure research, but to the degree that we do research with the view to setting standards, again, for the operation of business processes and industrial products.

Now, in that regard again, if my figures are correct, what I have here, in 4 years—of approximately 23 percent in the expenditures, 23 to 24 percent in the expenditures through appropriations, and an increase of about $70 million on a base of $182 million—whatever that percentage is—in terms of the total expenditures of the National Bureau of Standards in 4 years in the areas of standards development.

We think that is a substantial increase. And to go back to the opening questions, we would like for it to be a little bit more oriented to some of the new technologies as opposed to some of the old technologies if we could get those picked up by others.

The Congress has provided us the funds to do the old technologies, and we have done them, and we think we've done them very well.

Mr. Ritter. I don't want to get into the numbers because I think they've been well covered. And I would like to also put in a word on your behalf on our ability to redirect priorities. Anytime a Federal program is begun, it becomes lifelong, and probably even longer than our lifetimes—certainly in the Congress. If we want to make best use of our resources, whether at NBS or in other Federal laboratories or national laboratories, we have to be able to make those shifts, and I think it's going to mean some tough decisions and maybe fire and building research was one of those. So, I'm not really quibbling with that.

I guess what I'm trying to bring out here is the possibility that the Bureau of Standards' labs, within the framework of the Standards' mission, could become, should become, has the potential to become the preeminent Government industry cooperative arena for stimulating those areas which we know our adversaries are stimulating. And we know we need greater amounts of teamwork amongst our industrial players. We have the opportunity, if we do it right, to do so much more than just to hold the line and survive.

I mean, I'm fairly familiar with the situation within the labs and in and around the labs, and the discussions amongst the technical community about the labs, and we're really in a holding pattern.

Mr. Brown. Mr. Ritter, we think we are that agency. We think there is a good relationship with the private sector. We think it is perhaps as good as exists between any Federal laboratory and the private sector with which it's involved. We think we are recognized for that, and that's why I mentioned the awards that were given just this last week in private sector and public competition for—public sector competition in the technical community.

Mr. Ritter. Yes. And I think you understand that. I'm not sure OMB has the foggiest understanding of that, and they do provide the ultimate bottom line. I think we do have a problem in maintaining the caliber and quality and effectiveness of the Bureau. My point is that we shouldn't just be seeking to maintain or marginally acquire some additional resource, but the Bureau has the potential for, I believe, serving as the lynchpin of a Federal/private industrial competitiveness capability which we do not have now.

In no way, shape, or form does this country have anywhere near the equivalent, and I think we need it. And I understand that we have a philosophy that the Government is best off doing basic research, and I agree with—in terms of sponsorship—I agree with that. But in terms of serving as the focal point, the meeting ground, and the entrepreneurial function to put industrial teams together, the Bureau has that capability. And I think we have to magnify that capability not marginally, but by perhaps an order of magnitude in order to deal with this industrial competitiveness challenge.

I appreciate the works that you're doing to try to bring this about under difficult circumstances. I guess the bottom line is—let me ask you this question:

Is it possible to achieve this kind of growth and capability inside the Department of Commerce as a small segment of a Department whose overall mission is far-reaching and all too often quite different? Or do we need to think of a separation or some other kind of focus for the Bureau's capabilities?

Mr. Brown. It's my view that if the National Bureau of Standards stood alone, it would be less successful in the budget process than it is in the Department of Commerce. The Bureau of Standards, the Census Bureau, the Patent and Trademark Office, the International Trade Administration, all of which are in the Commerce Department currently, have a common mission. And that common mission is to serve the economic community; that is, the business community in this country that's involved in both domestic production and international trade, which is at the root of the economic health of the American society.

We think the Bureau of Standards has a very critical role in that economic community. It is not the same basic research unit that the National Science Foundation is. It is not the health research activity that the National Institute of Health is. It is not NASA focusing in the space area. Nor, yet again, is it the 70 percent of the Federal budget in research and technology that is undertaken by the Defense Department.

We think we've provided some leadership to all of those agencies, however, by trying to open the laboratories of the Federal Government to private sector usage. We have done that, we think, competitively, with private sector research organizations like AT&T and the Bell Laboratories, like General Motors, like Exxon, some with much more in the way of resources than we have in terms of the total budget of their agencies. The total budget of the Commerce Department is about $2 billion.

We have done very well in the National Bureau of Standards both in terms of the quality of the work and the focus of that work as it assists industry. We intend to continue to try to do better. But that's a function of budget and that's a function of hopefully the support of this committee when we submit the budgets to the Congress, and it does hinge on questions of whether we are to continue to look to cutting-edge activities or be limited in those and stick with the traditional, historic work of the agency. And that's ultimately a decision made in cooperation between the Congress and the administration and the budget, and the authorization, that are finally passed back to me and the Secretary to administer.

We propose, while OMB, the Congress, and ultimately the President, by his signature of veto, dispose, and we'll do the very best we can. We think that's very good at this point, given the resources we are able to get to work with.

Mr. Ritter. Well, I do commend you on the job that you're doing. What we're trying to do here—what I'm trying to do—is help you to do it better.

Thank you, Mr. Chairman.

Mr. Brown. We appreciate that help. Thank you.

Mr. Walgren. Thank you, Mr. Ritter. Let me just ask two other questions. You indicated that, as opposed to standing alone, you'd rather see the Bureau of Standards in the Commerce Department. You felt they would do better there.

What about some other structure such as a Department of Science and Technology? Do you feel that the Bureau of Standards might be more appreciated in a structure that's more sensitive to its contribution to scientific capabilities than would, by nature, the Department of Commerce be, in view of the wide range of the responsibilities of the Department of Commerce?

Mr. Brown. My preference personally, Mr. Chairman, is to see the Bureau of Standards stay in the Department of Commerce because I think, in the Department of Commerce, it can offer a greater contribution with reference to its mission, which we think is focused on the assistance to American industry and developing competitiveness.

Mr. **Walgren**. Let me ask also—the Director at the Bureau has a competence fund—I don't know its exact amount at this point—but apparently it is to be used substantially at his discretion to move and encourage new initiatives when that's possible.

The President's Commission on Industrial Competitiveness recommended that the national laboratories have something in the range of 10 percent——

Mr. **Brown**. I think that recommendation was made by the Packard Commission, Mr. Chairman.

Mr. **Walgren**. I see.

Mr. **Brown**. Not the National Commission on Industrial Competitiveness.

Mr. **Walgren**. All right. Is that fully supported on your level along the line——

Mr. **Brown**. It is. We feel that the competence fund and the other discretionary funds, which the Director has available to him, are within that range limit.

Mr. **Walgren**. OK. Well, in closing, I do go back to that thought that in the exposure we had to the Bureau's available funding, we were not given to understand that there were certain carryover funds, which might have been used to do some things which we all wanted to do on this committee.

I hope that in the next budget cycle that we'll certainly be looking very carefully to try to understand just what resources are at your disposal in that particular area so that we can understand what can be done even without perhaps a specific appropriation.

Mr. **Brown**. Mr. Chairman, if I recall correctly and put the proper value on the authorization of the appropriation to process, I'd have to say that both the authorizing committee and the Appropriations Committee are very important to us in the carrying out of the mission of the Department as it's reflected in the Bureau of Standards.

We continue to solicit the support and the interest of this committee in new initiatives and in the full authorization for the activities of the committee. We also continue to solicit the support of the Appropriations Committee to provide us the funds we request, as those requests are limited by the process that we go through; to make a proposal to OMB and have OMB ultimately prepare the President's budget for submission to the Congress.

It's my hope that we can have open dialog with all the members of the committee either collectively or individually on the budget process. I'm available by phone or will be up here as quickly as I can get here to discuss with you anytime the authorizations that we think keep us on the cutting edge of technological development. We're anxious to have those authorizations from this committee because we think the committee is just as interested as we are in the Department in seeing that the Bureau of Standards continues to work in those new areas of technological development when it is timely for them to do so, and efficient to see that America's competitiveness is maintained and improved at the highest level possible.

The committee has always been very supportive of the Bureau. We want the Bureau's work to reflect the interests of the committee, and the interest of the administration. And we will continue to try to work with you.

Mr. Walgren. Any chance of the cold neutron source being supported in the continuing or supplemental appropriation request?

Mr. Brown. It's already—the supplemental appropriation will have the cold neutron in it. We proposed it last year, as you know, as an authorization appropriation. We lost that in the Congress. That's one of the reasons that we were here at the last minute discussing the authorization and the appropriations, because we were concerned about the loss of the cold neutron source.

Mr. Walgren. OK. Well, on behalf of the committee, let me thank you for your courtesy. I realize we've kept you over an hour beyond the time that——

Mr. Brown. I found a substitute for my 11:30 appointment, I hope.

Mr. Walgren. Well, thank you very much for being available to us, Mr. Secretary. There's a roll call on the floor. We ought to adjourn very briefly—and I apologize for how long this has gone on—we do have a very substantive panel left, which we want to finish inasmuch as you've all gone so far out of your way, and we're in full flight here.

So, let's take a very short break and then turn to that next panel between 12:30 and 12:45, or thereabouts.

[Whereupon, a brief recess was taken.]

Mr. Walgren. Let's proceed. Dr. Branscomb is very familiar to the committee and to these levels of discussion. He's now the chief scientist and vice president at IBM. Dr. Betsy Ancker-Johnson, who is the vice president for General Motors environmental activities staff, and Dr. William Slichter, the executive director for research of the materials science and engineering division at Bell Laboratories.

Welcome to the committee, folks. We appreciate your patience and apologize for this having gone on as long as it has. As you all know, the written statements will be made part of the record, and you can feel free to summarize or outline or underscore points that you feel would be most helpful to focus on.

Why don't we go in the order that we called you? We'll go through the whole panel and then maybe have some opportunity for discussion.

Dr. Branscomb.

STATEMENT OF DR. LEWIS M. BRANSCOMB, CHIEF SCIENTIST AND VICE PRESIDENT, IBM

Dr. Branscomb. Thank you very much, Mr. Walgren. It's a pleasure for me to speak as a former director of the Bureau of Standards, as the vice president and chief scientist in a company that depends to a significant degree on the health of the Bureau of Standards, and as a scientist who cares about the Bureau of Standards.

With your permission, I will just highlight my testimony if indeed it is to be put into the record. I was very impressed with Mr. Ritter's vision and with some of the other questions this morning, and with Mr. Clarence Brown's sincerity in his support for the Bureau of Standards and its mission.

I must say, though, in one respect I'm disturbed by Mr. Brown's characterization of the mission of the Bureau of Standards as being related—it seems to me he said exclusively to the issue of industrial standards. I think it is terribly important to remember that science cannot progress without a foundation of accurate measurements. And the scientific progress of this country depends in no small measure on the health and vitality of the National Bureau of Standards.

If the Bureau of Standards were in fact to become simply a laboratory devoted to the development of test methods and of technologies or technical knowledge for use in industry standards, it would become a pale shadow of its present self and certainly of its glorious history.

The reason the Bureau of Standards is highly respected in the scientific community is because of the extraordinary dependence that science has on accurate measurement, on the characterization of materials, and on the other kinds of work done at the Bureau.

Second, I was a little disturbed with his differentiation between the Bureau of Standards as a Commerce agency and the mission of the National Science Foundation, when he comments that the Science Foundation has a role in basic research—which is of course true.

The reason that disturbs me is that my own experience, a good many years at the Bureau of Standards, is that the best way to get accurate measurements techniques invented, the best way to get first rate technical work done in support, indeed, of the needs of industry is to hire scientists into an institution whose institutional culture is devoted to accuracy and precision. And then set them the task of doing research that motivates them of the highest order.

If they believe they're doing basic research, they will put out terrific measurement science and great standards. If you hired them as hired hands on a project basis to go do standards development, they'll do it, but it won't be world leading and it certainly won't serve the needs of science.

So it seems to me we absolutely mustn't lose sight of the dependence of the scientific progress of this Nation on the National Bureau of Standards. And I accord that a higher priority than I accord support for industry.

Now, having said that, I would quickly add that I believe support for our economy is the second most important mission of the Bureau of Standards, and of course from a pragmatic point of view, or at least an economic point of view in the near term or relatively near term, the most important mission.

Now I would like to note that what Mr. Brown claims for the Bureau is correct, and what Mr. Ritter advocates is, in my opinion, visionary and correct. Namely, the Bureau of Standards is the Federal research agency that best bridges the gap between the Government and industry. To me it is a tragedy of no small proportion that in all the debate we have had in this Nation for the last many years, but peaking up in the last 5 or 6 years, about the Federal Government's role in support of the technological competitiveness of the private economy, which certain people would refer to as industrial policy and others prefer not to call it that, there seems to be a unanimity that the Bureau of Standards' mission is the one mission everyone can agree upon as appropriate.

Yet, somehow, there is no rallying around the building of this agency to be the kind of thing Mr. Ritter was talking about. I feel that's in part because of a lack of understanding of the relatively subtle distinctions between research activity, and participation in the private sector's standards process, the development of technologies.

It was said earlier here today by Mr. Brown that it's probably a good thing the Bureau of Standards didn't get into optical fibers earlier because had the Bureau of Standards gotten into optical fiber technology, they would have wasted money and wasted time. I agree. The Bureau of Standards has no business trying to develop optical fiber technology. They're totally outclassed by the resources at AT&T and Corning and Japanese companies and others.

But they should have been involved very early in the metrology of optical communications. And I'll defer to my colleague on my right from Bell Labs to elaborate on that with his own views. But there is always a mixing up of the Bureau's role as a scientific laboratory devoted to measurement to support both science and industry, and the possibility that the Bureau of Standards should be put to work developing industrial technologies—something which I happen to oppose and I think many people oppose on both sides of the aisle. There is a big difference.

Let me also note that in the Bureau's contribution to industry, it's hard for the Bureau of Standards to make the case for the value of its contribution. It doesn't subsidize anything and it doesn't make grants of money to industry. It shouldn't and it doesn't. Its achievements are a long series of anecdotes, each of which is a small but vital technical contribution that benefited some segment of industry substantially.

You put all these anecdotes together—and it would take a long time to listen to the story—you have to be persuaded that what it does is important. Yet it's impossible to make a cost-benefit calculation. That does not surprise those of us from industry. It's interesting that in our companies we do not—at least in my company—we do not ask our corporate research laboratory to cost justify their work. We ask them to persuade us that they're working on important problems and that they have the best people they can possibly get working on them. That's what this country should ask of the National Bureau of Standards.

We should also ask of our corporate laboratory—of the Bureau of Standards, tell us what you've done for us lately. If you haven't got a pretty good answer to that, then there's a sign that something is wrong. So let me tell you at least one thing the Bureau of Standards has done for us lately, and I'll just draw this from my own experience.

A year ago a lot of our customers discovered they had a very strange and not understandable problem with contamination of some of their computer equipment. And nobody could understand the source of the contamination. A lot of sleuthing was involved in tracking it down to the use of biocides in the air—the water towers or air-conditioning systems in large buildings, when those air-conditioning systems were also cooling computer rooms.

The solution to that problem, of our customer's problem by the IBM laboratories depended quite precisely upon a piece of work done at the Bureau of Standards and published in a very sophisticated measurement technique called laser enhanced flame ionization spectroscopy, which permits the improvement by a factor of between 100 and 1,000 in the precision with which one could detect certain organometallic compounds in air. And with that technique we were able to discover these tenths of a part per million of this biocide in the air streams coming into the cooling of this piece of computer equipment, which in certain circumstances was being damaged by this contamination.

Our folks give the Bureau of Standards full credit for that achievement. And I should also point out that our people published their results extending this measurement method in the particular application we used so that it is now available to everybody.

The Bureau's history is full of stories like that. Hundreds of millions of dollars in the economy depend upon specific incidences of that kind. And it's a fine story that needs to be heard, and I welcomed the opportunity to tell it.

I'd like to make a comment also about the Bureau of Standards' integrity. When I was director, I regarded that as the Bureau's most precious asset and a factor that distinguishes it most clearly from other institutions. I'm not implying that other institutions lack integrity. What I am saying is that the Bureau of Standards' function depends upon the acknowledgement that its integrity is not easily assailed.

Reference was made earlier to the episode back in 1953 with battery additive ADX–2, from which the Bureau emerged with flying colors. That process has happened repeatedly since.

The Government very badly needs somewhere in its family a broad purpose agency whose integrity is unassailable, which can become the technical adjudicator where controversy exists. And I would point out that that integrity is not a cheap thing to maintain. It requires not only a superb staff, but a staff that has so much confidence in their own scientific capability, that they would be willing to put their jobs on the line if that became necessary if their integrity were challenged.

If the Bureau of Standards' technical resources were to dwindle over a long period of time, and degraded the integrity of the Bureau to the point where it became just another national laboratory, a job shop for work, I believe that would be a tragedy, indeed.

Let me also make a comment about the Bureau's scientific vitality. For having said that its most important mission is to support the productivity and the inventiveness and vitality of American science, obviously that can't be done unless the Bureau possesses those qualities itself. More than any other thing, that depends upon the young people they bring in.

I was very disturbed to hear earlier this morning that there is some attempt to start chopping down the entry of young scientists into the Bureau of Standards. I also have been given the impression that the Bureau's post doctoral program is under fire from within the Government. Should the Bureau be unable to bring in a steady stream every year of the brightest people that it can attract to work in a Government laboratory for Government salaries, but a very fine laboratory indeed, then the Bureau is on a downward spiral from which it will soon not recover.

And that brings me to the last point I want to make, Mr. Chairman, which has to do with the problem that has consumed most of the time this morning. How can the Bureau of Standards remain a vital laboratory and respond to new challenges, and yet still keep up with old challenges?

And the answer—there's no magic answer. I think we all know the answer. First of all, it cannot be a vital laboratory unless every year it hires a significant, though modest number, of the brightest young people who are allowed to work in the newest and most exciting areas of science.

To do that, it would have to grow, unless it had a way to shrink. There is a right way and a wrong way to shrink. The worst way to shrink is to be ordered from on high precisely how you are to shrink. That issue must be left to the Director of the Bureau and his management. To do anything else is micromanagement from levels of Government that do not possess the knowledge of how to run a laboratory.

The next worst way to shrink is to tell the Bureau of Standards to atrit by some fixed fraction every year with the Director free to choose how he will take that cut.

The best way to shrink is the way historically, since 1901, the Bureau has done its shrinking. And that is, that it has shown periodic steady, but modest, growth until one of its major functions is ready to be spun-off. I would remind you the Bureau is the parent of NOAA. It is the parent of NASA. It has created any number of major institutions that have long since outgrown the Bureau of Standards, their own parent. And it needs to do that again in the present resource crunch.

I listened with fascination this morning when it was suggested that maybe the administration ought to go to work on the task of figuring out how to institutionalize the fire research program without the need for Federal funds. I would submit that's an excellent project to undertake. The best way to start is for the administration to come forward with the leaders of that industry and have them testify before this committee to the effect that they are prepared to pick up this fine institution, and here's the institutional framework within which they will do that, and be sure that that's satisfactory to those who are concerned about the insurance industry, the fire protection industry, the fire academies and departments of this country, and those concerned in consumer and public safety. And if they can be made to agree there is a way to do it, then that's what we ought to do.

When I was Director, I would dearly have loved to have had the Bureau in a purely modest technical support role to some nongovernmental institutions to do that job. We were not able to put such an institution together. Maybe brighter people or maybe the passage of time permits it, but absent any evidence for it, I don't think abandoning the project with the assumption that somebody will pick it up is likely to be a successful experiment.

The same thing applies to the building industry, the building technology laboratory at the Bureau, with the additional caveat that I think one has to admit that the building industry is an industry. We heard remarks this morning that suggested that there's the building technology center and its interested constituents, and then there's industry. Well, there is an industry here.

I think Mr. George Brown was absolutely right when he said the difference between the high tech industries and the building industry is the fragmentation of the building industry—which makes it so difficult to put together a national capability that doesn't depend on so much Federal resource.

But I would also observe as another element in the building technology center that wasn't mentioned this morning, and is almost never mentioned these days, and yet it seems to me of enormously increasing importance, and that's the relationship between the Federal Government and the States.

When I was the Director, the most important thing the Bureau of Standards did in the building technology field had nothing to do with helping industry directly. It was indirect both to industry and to consumers by working on the 13,500 independent building code jurisdictions we have in this country, to decrease that number by encouraging the States to take that task on. And the Federal-State relationship in the building area strikes me as the key to aggregating the industry on a more national level so that it can demonstrate a better capability to develop its technology.

So I submit that there, too, there's every opportunity to try to create a new institution. But to kill the old institution before the new institution has been designed and committed to is, it seems to me, a mistake.

But I also have to be here complaining about the fact that for some reason I cannot fathom an administration that says it wants the Bureau of Standards to expand its activities in the high tech, most current, most rapidly growing sectors of the economy, and yet seems very lukewarm about having a computer science and technology institute at the Bureau of Standards.

Both my company and CBEMA, the trade association, are on record with this committee and others as favoring that institute. The industry will be $1 trillion industry worldwide early in the next decade. And it strikes me as shortsighted and extreme that the Bureau of Standards wouldn't have considerable capability. As a matter of fact, I think the tragedy is that back when I was Director, we lost the battle to have the telecommunications agency as a part of the Bureau of Standards. And it has now largely withered away, at least in terms of technical capability.

To give a specific example of why we need a Bureau of Standards with competence in both telecommunications and computer technology, we have the case of open systems interconnect standards. This is a major international standards issue in which the European community and European governments and other governments around the world are deeply engaged, for there's more to it than just the desirability of being able to interconnect networks. There are major national competitive interests at stake.

We're not asking our Government to distort the international standards market to the benefit of U.S. companies. What we want is a technically competent voice—the Bureau of Standards being the obvious one—to come forward and keep the debate on the technical issues, not on the political or trade or protectionist issues. And at least from the Government's point of view, there is no other place in Government I know to look to have that voice of sane, technically sound international standards. And I assure you that the issues are of major proportions from an economic point of view.

So, let me just conclude by saying that I do think that too much of the discussion about the Bureau has been short term and tactical. I really believe we all need to find a shared vision of what it can be. There is every opportunity for compromise on the issue of the Federal role in bolstering our economy through trying to bolster the Nation's technical capability. And I think there is no doubt that the Bureau should be a centerpiece to that purpose.

Obviously a question which this committee has investigated before, and I'm sure will again, is the whole question of a department of science and technology. I won't take your time to launch into that now, but I think your question is well taken. It might well be that the place to start on that project is the examination of a microdepartment of science and technology which examines very seriously the relationship between the mission of the National Science Foundation, the mission of the Department of Commerce, and the proper institutionalization of the National Bureau of Standards.

Thank you, Mr. Chairman.

[The prepared statement of Dr. Branscomb follows:]

TESTIMONY FOR THE SUBCOMMITTEE ON SCIENCE, RESEARCH AND TECHNOLOGY, U.S. HOUSE OF REPRESENTATIVES

LEWIS M. BRANSCOMB
VICE PRESIDENT AND CHIEF SCIENTIST
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ARMONK, NEW YORK

HEARING ON THE FUTURE ROLE AND MISSION
OF THE NATIONAL BUREAU OF STANDARDS

OCTOBER 1, 1985

I am delighted to have the opportunity to speak to this distinguished committee about the National Bureau of Standards, a unique institution of extraordinary value to the people of this country. My remarks will reflect the combination of my experience and views as a former director of the National Bureau of Standards, as Vice President and Chief Scientist of a company that depends to a significant degree on the health and effectiveness of the National Bureau of Standards, and as a scientist who cares deeply about the vitality of America's great laboratories.

I would like to make a few points in my prepared testimony that I am prepared to discuss further if the committee wishes. I will start by making four categorical statements and then amplify each one to some degree.

1. Even though the Bureau has many useful, even applied tasks to perform, it cannot perform them without a level of capability in fundamental science as high as that found in the very best of our universities.

2. THE BUREAU'S INTEGRITY IS ITS MOST PRECIOUS ASSET, THE FACTOR THAT MOST DISTINGUISHES IT FROM OTHER INSTITUTIONS, BOTH GOVERNMENTAL AND SCIENTIFIC.

3. THE BUREAU IS THE NATION'S INSTITUTION THAT BEST BRIDGES BETWEEN THE SCIENTIFIC COMMUNITY AND THE TECHNICAL LEADERS IN PRIVATE INDUSTRY, AND THUS PLAY A UNIQUE ROLE IN THE CONTRIBUTION OF AMERICAN SCIENCE TO GROWTH OF OUR ECONOMY.

4. THE BUREAU IS THE MOST FLEXIBLE AND THE MOST BROADLY COMPETENT OF THE NATIONAL LABORATORIES AND MUST BE ALLOWED TO BUILD ITS CAPABILITY IN NEW AREAS OF HIGH TECHNICAL AND ECONOMIC PRIORITY WITHOUT ABANDONING OTHER AREAS OF NATIONAL IMPORTANCE, ABSENT AN EFFECTIVE GOVERNMENTAL INSTITUTION TO WHICH TO SPIN OFF THOSE RESPONSIBILITIES.

Scientific Excellence

I am sure the Congress is very familiar with the great contributions NBS makes to a fair, efficient and growing economy through the development of test methods and participation in the voluntary standards process with industry. Scientifically sophisticated test methods are as crucial to industrial quality and cost control as they are to fairness in commerce and to the effectiveness of industrial standards.

But one must never forget that science itself cannot progress without accurate measurements. The health and productivity of American science, in industry, government and universities, is utterly dependant upon the quantitative base established by the National Bureau of Standards with the support of scientists in many institutions around the country, and indeed around the world.

Unless the Bureau is supported to be the queen of American scientific laboratories, providing the underpinnings for rapid advances in many areas of physical science and mathematics, it will not be able to do its job in the more engineering and industrial areas.

BUT THE GREATEST DAMAGE TO THE NATION WOULD COME FROM A SLOW-DOWN IN THE PROGRESS OF SCIENCE ITSELF. WHILE IT IS EXTREMELY DIFFICULT TO MEASURE THE PROGRESS OF SCIENCE, AND HENCE TO DOCUMENT QUANTITATIVELY THE COST-EFFECTIVENESS OF INVESTMENTS IN NBS MEASUREMENT SCIENCE CAPABILITY, THE JUDGMENT OF INDUSTRIAL AND ACADEMIC LEADERS EVERYWHERE IS, AS FAR AS I KNOW, UNANIMOUS ON THIS POINT.

SCIENCE IS THUS THE BUREAU'S FIRST PRIORITY BECAUSE OF THE VALUES IT BRINGS TO THE NATION. SUPPORT FOR INDUSTRY IS A VERY IMPORTANT SECOND.

IN THIS CONNECTION, ALL THE PERSONNEL AND ADMINISTRATIVE PRACTICES THE BUREAU HAS INVENTED OVER THE YEARS TO ENSURE ITS EXCELLENCE ARE TERRIBLY IMPORTANT TO ITS CONTINUATION. IMPORTANT AMONG THESE IS A STEADY INFLOW OF THE BRIGHTEST YOUNG SCIENTISTS AS WELL AS A SIGNIFICANT NUMBER OF GUEST SCIENTISTS OF MORE MATURE EXPERIENCE. THE BUREAU'S POSTDOCTORAL PROGRAM, FOR EXAMPLE, IS A CRITICAL TOOL, ESPECIALLY AT A TIME WHEN THE BUREAU'S TOTAL STAFF IS NOT GROWING -- INDEED, HAS BEEN SHRINKING. THE COMMITTEE SHOULD ENSURE THAT THIS POSTDOC PROGRAM AND SIMILAR ACTIVITIES ARE NOT THREATENED BY MORE TACTICAL BUDGETARY CONSIDERATIONS.

But the most critical requirement is that the Bureau continue not only to recruit the most outstanding young scientists, but that it be able to offer them the best conditions for fundamental research in a quantitative environment. I have documented, in an address to the Argonne National Laboratory -- an address I am pleased to submit for including in the record at the committee's pleasure -- the fact that offering young scientists freedom in the opportunity to pursue science in the Bureau's intellectual environment is indeed the best management method for ensuring that they contribute directly to the more practical aspects of the Bureau's mission.

Integrity

Over many decades the Bureau has served as the closest thing the Federal government has (or should have) to a "science court". In countless cases over the years the Bureau's technical evaluation in the field of failure analysis and in many other areas has been critical to settling issues of great concern to the public, often involving billions of dollars, and always in the caldron of political conflict. Even when subjected to the most difficult challenge to its integrity, as in the famous case in 1953 concerning battery additive ADX-2, the Bureau has emerged with its integrity intact.

WHAT IS NEEDED TO SUSTAIN THE BUREAU'S INTEGRITY? FIRST, THE GOVERNMENT SHOULD CONTINUE TO DEPEND UPON ITS EXISTENCE, FOR EXERCISING ITS REPUTATION FOR INTEGRITY IS THE BEST WAY TO TRAIN NBS MANAGEMENT IN THE STEWARDSHIP OF IT.

SECONDLY, SCIENTIFIC INTEGRITY CANNOT COME WITHOUT COMPETENCE. THE SCIENTISTS MUST BE ORDERLY, CONFIDENT THAT THEIR METHODS AND THEIR JUDGMENTS ARE THE BEST MODERN SCIENCE ALLOWS. THEY MUST ALSO HAVE CONFIDENCE IN THEIR OWN CAREERS AND THE ABILITY TO FIND A HIGH DEMAND FOR THEIR SERVICES SHOULD IT EVER BECOME NECESSARY TO PUT THEIR JOBS ON THE LINE WHEN THEIR INTEGRITY IS CHALLENGED.

INTEGRITY DOES NOT COME CHEAP. THE GRADUAL STARVATION OF THE BUREAU'S TECHNICAL RESOURCES WOULD HAVE THE INEVITABLE CONSEQUENCE OVER A LONG PERIOD OF TIME OF DEGRADING THE INTEGRITY TO THE POINT WHERE THE BUREAU BECOMES "JUST ANOTHER NATIONAL LABORATORY." THAT WOULD BE TRAGEDY INDEED.

A BRIDGE BETWEEN SCIENCE AND INDUSTRY

WITH ALL THE DEBATE ABOUT FEDERAL POLICIES IN RELATION TO THE TECHNOLOGY ASPECTS OF ECONOMIC DEVELOPMENT, AND ALL THE POLITICAL DIFFERENCES THAT EXIST ABOUT "TECHNOLOGY POLICY," THE ONE SUBJECT ON WHICH EVERYONE SEEMS UNANIMOUS IS THE IMPORTANCE AND VALUE OF THE BUREAU'S ROLE IN THIS RESPECT. AND YET, I SUSPECT THAT THE STORY GOES LARGELY UNHERALDED.

THE PROBLEM IS THAT THE BUREAU'S CONTRIBUTIONS ARE MADE THROUGH INDIVIDUAL EVENTS OF SCIENTIFIC ACHIEVEMENT OF GREAT VALUE TO INDUSTRY. SOME OF THESE EVENTS FIND THEIR WAY TO INDUSTRY THROUGH THE SCIENTIFIC LITERATURE. IN MANY OTHER CASES THEY ARE THE RESULT OF DIRECT CONTACTS, EVEN COLLABORATION WITH INDUSTRIAL SCIENTISTS. IN ALL CASES THEY BECOME PART OF THE OPEN SCIENTIFIC LITERATURE AND CAPABILITY OF THE COUNTRY, SHARED BY ALL WHO CARE TO BENEFIT.

LET ME GIVE AN EXAMPLE FROM IBM'S EXPERIENCE IN THE LAST TWO YEARS. WHEN OUR CUSTOMERS RAN INTO A VERY COMPLEX TECHNICAL PROBLEM CONNECTED WITH THE USE OF ORGANOTIN BIOCIDES IN AIR CONDITIONING SYSTEMS, WE WERE ABLE TO SOLVE THE PROBLEM ONLY AFTER LEARNING OF A NEW MEASUREMENT METHOD DEVELOPED BY SCIENTISTS AT THE NATIONAL BUREAU OF STANDARDS.

THIS MEASUREMENT METHOD, INVOLVING AN INGENIOUS COMBINATION OF DIFFERENT TECHNIQUES, MADE IT POSSIBLE TO DETECT TRACE IMPURITIES A HUNDRED TIMES SMALLER THAN THOSE THAT COULD BE MEASURED BEFORE.

WITHOUT THIS KIND OF SCIENTIFIC SUPPORT FROM NBS, HIGH-TECH INDUSTRIES CANNOT AFFORD TO TAKE THE RISK OF TRYING TO ENGINEER PRODUCTS THAT ARE BEYOND THE FOREFRONT OF CURRENT SCIENTIFIC KNOWLEDGE.

THE BUREAU'S INDUSTRIAL GUEST WORKER PROGRAM IS EXTRAORDINARILY HEALTHY, BY ALL REPORTS, AND REPRESENTS A POSITIVE COLLECTIVE JUDGMENT BY INDUSTRY ON THE QUALITY OF WORK THE BUREAU OF STANDARDS IS DOING THAT IS OF DIRECT INTEREST TO THESE COMPANIES, LARGE AND SMALL. TO BE ABLE TO PROVIDE THE BENEFITS OF ACCEPTING INDUSTRIAL RESEARCH ASSOCIATES, THE BUREAU MUST BE ABLE TO MAINTAIN, ON ITS OWN APPROPRIATION, THE CORE PROGRAMS THAT PROVIDE THE COMPETENCE THE PRIVATE COMPANIES WILL SEEK OUT. INDUSTRIAL RESEARCH ASSOCIATES ARE NOT A SUBSTITUTE FOR NBS CAPABILITY; THEY ARE A RESPONSE TO IT, A GREAT VALUE TO THE COUNTRY.

NEW CHALLENGES AND CONTINUING RESPONSIBILITIES

WHEN I WROTE TO THE COMMITTEE LAST MARCH, THE BUREAU WAS BEING ASKED TO MAKE SOME DRACONIAN CHOICES BETWEEN RESPONDING TO IMPORTANT NEW CHALLENGES WHILE MAINTAINING ITS RESPONSIBILITIES IN AREAS THAT CONTINUE TO BE OF GREAT IMPORTANCE TO THE COUNTRY.

THE MAJOR EXPANSION IN MATERIALS SCIENCE, PROPOSED A YEAR AGO, IS VERY MUCH NEEDED BY BOTH SCIENCE AND INDUSTRY. IBM IS IN THE MIDDLE OF A MAJOR SUPPORT PROGRAM TO AMERICAN UNIVERSITIES IN JUST THIS AREA, BECAUSE OF THE EXTENT OF OUR INDUSTRY'S DEPENDENCE ON CERAMICS AND POLYMERIC MATERIALS. THUS, WE STRONGLY SUPPORT THE BUREAU'S PLANS TO GET INTO THOSE AREAS, PARTICULARLY IF THE BUREAU FOCUSES ON THE MICROSTRUCTURE AND SURFACE SCIENCE ASPECTS OF MATERIALS OF GREAT IMPORTANCE TO THE ELECTRONICS INDUSTRY.

We would, however, deeply regret seeing this work taken on at the expense of the Bureau's continued capabilities in computer science and technology. It is vitally important to the industry that a Federal laboratory with a mission in voluntary standards and in measurement science have competence and depth in the computer field. This has never been more important then it is today, with not only governments but communities of governments yielding to the temptation to use international standards processes to further their own goals in international economic competition.

To give you an example, there is major activity around the world concerned with Open Systems Interconnection standards for computer communication. The National Bureau of Standards has competence in this area and an important mission to insure that technical and economic realities are put first in the standards debates, not maneuvering for differential national advantage. We also feel it is important that the Bureau continue to maintain responsibility for the integrity of testing to determine whether commercial offerings are consistent with adopted standards.

It seems to me very strange that Government officials in 1985 would suggest that the Bureau close or substantially reduce the scope of its Institute for Computer Science and Technology, when recent projections for this industry anticipate a trillion dollar worldwide revenue in the early 1990s. Other industries can, I'm sure, make similar cases about the Bureau's historic work in building technology and fire research.

The Bureau of Standards must be allowed sufficient growth to respond to the new opportunities without precipitously disengaging its capability in areas in which there is a national dependency. This does not mean that the Bureau must continue to work in every area, growing without limitation. One only needs to look at history to be reassured that the Bureau has never done that and, doubtless, never will. From time to time, it spins off major operating units to help create new agencies that carry them on independently.

The Bureau can proudly claim parenthood for the National Oceanic and Atmospheric Administration, the National Aeronautics and Space Administration, and many other fine national institutions.

It could do so again in areas like fire research, if the Congress and the Administration can agree upon a technically competent supportive home for such an activity. To abandon it in the hope that the private sector would carry out the work done by the Bureau without a clear plan and fixed commitments would not be a responsible act.

In summary, the Bureau has served this country with extraordinary distinction and proved its adaptability to current circumstances and to the President's policies over quite a range in the past.

In only 16 years it will have completed 100 years of public service. Throughout all the upheavals, the periods of growth and the periods of entrenchment, the most important question at issue was the Bureau's technical vitality and its reputation for competence and integrity.

The Congress is ultimately responsible to sustain this fine institution, and I'm delighted that this committee is fulfilling that responsibility with such thoroughness.

Thank you.

National Laboratories in the Nineties

Lewis M. Branscomb
Vice President and
Chief Scientist
IBM Corp.

Director's Special Colloquium
Argonne National Laboratory
Argonne, Illinois

It is a feature of our society that public attitudes can be mercurial, but institutional structures are typically slow to change. This interchange of the moods and the machineries of our society describes both its capability to respond to change and its ability to accept discontinuities with minimum disruption.

The institutions that have been most successful over the long-term are those that have been able to discern secular changes of long-term importance and adapt to them, while preserving the most valuable elements of past tradition.

I don't know many things that have changed more rapidly, or are more subject to change in the near future, than the nation's commitment to science and technology. Yet, no scientific institution has proved to have more staying power, in the presence of predictions of radical change, than our national laboratories.

This afternoon, I will try to identify some of the secular changes, define some of the enduring values of national laboratories, and suggest some principles, if not directions, that might guide their future evolution.

The Tradition of National Laboratories

The national laboratories exemplify a tradition that goes all the way back to the U.S. Coast and Geodetic Survey in the 1790's. As significant institutions for the conduct of laboratory research, however, the tradition begins, perhaps, with the founding of the Bureau of Standards in 1899.

Although small at its beginning (the Bureau, in fact, predates the American Physical Society by two years), the pattern of its organization and mission set the stage for steady growth that brought it into substantial prominence in the 1920's as a large laboratory whose resources could be deployed by a scientific management to important national purposes.

I will use that as my definition of a national laboratory: a Federally-sponsored institution purposefully deploying research and engineering resources to national goals.

The history of the Bureau between 1910 and 1940 demonstrates a great many features of a national laboratory: flexibility to cover a range of activities from pure science to industrial technology, the responsiveness to switch emphasis from one to the other as times dictated, the ability to generate and spin-off new institutions, and the ability to serve official Government purposes.

The Bureau's research in atomic spectroscopy laid many of the foundations of the modern quantum mechanics. During World War I, when the United States was cut off from German optical glass — a dire military necessity — the Bureau of Standards created what became the U.S. optical glass industry It did the same thing in World War II when, in similar circumstances, a synthetic rubber industry was needed in a hurry. A few years later, the same laboratory did the experiments that first demonstrated the non-conservation of parity in weak interactions.

The Modern National Laboratory Concept

The modern national laboratory concept was ushered in after World War II, when the Radiation Laboratory at MIT, its sister at Berkeley, and the University of Chicago laboratory that was the progenitor of Argonne and Los Alamos set a pattern for university management of laboratories operated outside the Civil Service system

As time evolved, these laboratories matured into three families of powerful institutions belonging to the Department of Energy and its predecessors, NASA and its predecessors, and the Department of Defense To these one can add the family of general purpose laboratories in the military and at the National Institutes of Health, and a large number of more specialized laboratories, some of whose missions were broad enough to give them a national laboratory personality.

The high point for this system of Government laboratories occurred in the late 1960's. I was, at that time, chairman of the Committee on Federal Laboratories of the Federal Council for Science and Technology. This was a serious undertaking, and Administrations of the day understood that these laboratories were an important asset They were also very numerous. We compiled an index to all Government laboratories, and my recollection is there were over 1,000 institutions in this index. The laboratories were controversial, even then. There was a lot of pressure to farm their work out to private industry.

Many years later, I had occasion, as chairman of the National Science Board, to prepare the citation for awarding the Board's Vannevar Bush Award to Bill Baker of Bell Telephone Laboratories In that citation, we applauded Baker's generosity in assisting many lesser-known but important Government laboratories that went unsung and unappreciated but did good work and needed help. I cited as an example the U.S. Quartermaster Corps Laboratory in Natick, Massachusetts, for it had done very important research, and Bill had been chairman of its advisory committee for years.

When the Science Board staff was checking out this part of the text, they called the Office of the Assistant Secretary of the Army for Research and Development, which called me back and informed me it was a good thing we checked, because the Assistant Secretary for R&D said there was no such laboratory

Yes, Virginia, there is a U.S. Quartermaster Corps Laboratory in Natick, Massachusetts — alive and well, and still interested in the use of radiation to preserve food in a safe and more palatable fashion for the Army to use in the field, and a lot of other interesting things.

A number of Government laboratories have, in fact, disappeared in recent years. The White House Science Council Federal Laboratory Review Panel, chaired by David Packard, was only able to count "over 700." A very few new ones have been created. But virtually all of the major national laboratories have persevered in varying degrees of good health but with their facilities, talented staffs, and their hopes for the future largely intact.

National Laboratories as Perennial Targets

Forecasts of the demise of the national laboratories have consistently proved premature. Yet, they have been the perennial targets for morbid diagnosis. The Packard report, whose recommendations the President officially accepted August 5th, pointed to their effectiveness being "undercut seriously by vagueness and inconsistencies in some of the laboratories' missions."

In the earlier years, most of the criticism focused on the Civil Service laboratories, not on the Federally-funded research centers.

I remember once, in the middle 1960's — when Don Hornig was Science Advisor — it became necessary to have yet one more President's Science Advisory Committee study of what to do about the Government laboratories. Al Hill of MIT, a veteran of science policy from World War II days, undertook the task of heading the panel to do this major project

It was thought that his panel would require six or eight months to make an analysis, generate recommendations, and come back with a consensus report. In fact, he did the job in two weeks and came back to the next meeting with a single-page report which I shall never forget.

On a matrix, he displayed in columns about 14 recommendations. You can guess what they were:

- Strengthen the laboratories' top management, for which better compensation would be necessary.
- Give each laboratory the flexibility to deploy five to ten percent of its resources, as it chooses, without headquarters approval.
- Update and stabilize the missions of the laboratories.
- Introduce stronger connections to universities — for example, with on-site thesis work and a flexible post-doctoral program.
- Improve the linkages between the laboratories and the agencies and offices expected to benefit from, or implement, their output

Down the rows of this matrix, Hill simply listed the names of 14 previous studies made for the Executive Office of the President on the subject, "What shall we do about the national laboratories?" And wherever one of those reports had made one of those recommendations, he put an "x." There were very few intersections of rows and columns without an "x."

"My recommendation," Al Hill concluded, "is that you pick any of my 14 predecessors' studies and implement their recommendations." He then sat down

Well, of course, very few of those recommendations were fully implemented, but Hill did make an important contribution His report had a good effect. There were no more studies of national laboratories for a long time — perhaps even until the Packard study of 1983 — and, by the way, that report covers almost exactly the same ground as Al Hill's matrix

The Case for Restructuring Federal R&D Strategy

Now, a case can, in fact, be made that a restructuring of the Federal research and development strategy, and its institutional underpinnings, is overdue. The driving force for this case is that, in many people's minds, the major challenge facing American science and technology is economic, rather than deriving from narrower Federal government missions such as space, defense and energy.

Given the changed relationship between the science, engineering and education communities, on the one hand, and the economic institutions of the private sector on the other, it would be no surprise if radical institutional change were suggested.

The national laboratories' aggregate budgets do represent a very substantial fraction of the total disposable Federal research investment. A significant fraction of their work is not irrevocably tied to a mandatory Federal mission. Much represents an important area of Federal support for a vital, general-purpose national scientific and technical capability — albeit in disciplines tied to main missions.

This breadth of activity is just what makes groups like the Packard panel nervous about mission definition and stability. These very substantial resources, deployed against relatively broad and general objectives, make the national laboratories both a valuable asset and a potential source of resource reprogramming — which is a polite way of saying people envy the labs their budgets.

When the squeeze on Government research investments became most severe — largely due to the inflation of the 1970's and the failure to grow appropriations — the first and most natural targets for reprogramming were major Government demonstration programs. Most demonstration projects were too technically conservative to test technology, and too protected to test market forces. This conclusion reached consensus during the Carter Administration, and the Reagan Administration made pretty quick work of most of the remaining demonstration projects.

The national laboratory budgets are the next largest plum on the budget tree to examine. The universities looked on enviously, as did the Federal agencies and surely the OMB budget trimmers.

Values of the Laboratories, As We Know Them

Should the national laboratories, as we know them, be preserved in spite of these pressures? To answer that question we need consensus on values that attach to them. Let me reach into my own experience at the Bureau of Standards for a personal point of view.

I went to work with the National Bureau of Standards in 1951, primarily because I had tried to do a physics experiment when I was at Harvard that was too hard to do — even in an excellent university.

Wade Fite, now a physics professor at the University of Pittsburgh, had tried as a graduate student to be the first person to directly observe, in the laboratory, the continuous photo-absorption of the atomic negative ion of hydrogen in the free state. This is the process which Rupert Wildt had predicted, theoretically and correctly, is responsible for the temperature of the solar photosphere and thus for the whole sustenance of life on this planet.

Wade had failed in that experiment, changed his thesis topic, and gone on to become one of the top atomic physicists in the country. As a brand new Junior Fellow, having just gotten a Ph.D., I decided to try the experiment myself. After a year and a half of fruitless effort at Harvard, I accepted Ed Condon's offer at the Bureau, set up the appropriate facilities, and went to work again.

At the Bureau, I had colleagues who were experts in all the technologies I had to use. I had access to the Bureau's master German instrument makers — people who could accomplish incredible feats. I was in a laboratory with a tradition of patience ... of willingness to undertake an extremely difficult job and not give it up until the systematic, as well as statistical, errors were all in their place. I even had a technician.

After two years, I was almost able to get every piece of the equipment running simultaneously — but not quite. I called up Wade Fite, then at General Atomic, to come help me. He and I worked night and day over a Thanksgiving long weekend, and late Sunday afternoon we got the experiment to work. I don't think that experiment could have been done in a university in 1953.

In those days, young Ph.D.s at the Bureau, just like young scientists today at Argonne or Brookhaven, spent a lot of lunch hours arguing about what we thought we had to do to justify the work we wanted to undertake — to justify our positions in the laboratory, funded at public expense.

Indeed, one thing that politicians and public leaders don't understand is that scientists *do* think about why it is that their work should be supported by the public. Most scientists I know push themselves hard, in the interest of good scientific output, to understand how their science contributes to the future of their institution.

Some of us, in those lunchtime discussions, bought the argument that most people would probably use today: namely, that we could articulate why our work was essential to the mission of the laboratory, and thus fulfilled the Congressional expectations of public benefits.

The argument that I felt we ought to use then was different. I felt it didn't really make any difference whether any particular project at the Bureau of Standards contributed or didn't contribute to accurate and reproducible measurement or the setting of fair and credible test methods, or fulfilled any of the Bureau's other specific missions.

Need for a Special Kind of Research Institution

I argued that the nation needed, as part of its total scientific endeavor, a special research institution for work that was different in the way in which it was approached and carried out, and catered to people with a particular point of view about things. There needed to be a place that offered a special attractiveness — a special home — to scientists who cared about accuracy.

It would be a laboratory where the national primary standards of measurement are invented, extended and maintained — which makes it easier to do that kind of research; a laboratory with unusually powerful shops, with professional technicians held in high esteem, with an institutional tradition for credibility — where writing a paper with quantitative errors would be an unusually severe embarrassment ... where publishing first was not necessarily the quickest path to immortality . . where experimental science was held in highest regard, and where the theoreticians were not content with solutions expressed in atomic units or other dimensionless variables.

Such a place would be a haven for people who are burning with curiosity about whether Einstein got the second-order Doppler shift right, people who believe that the speed of light might be anisotropic in space, after all, or people who think it would be a jolly idea to define the speed of light as an exact number of man's invention — thus irrevocably linking the units of time and length through measurements on laser frequency and wavelength.

Such a laboratory, I thought, would invent for you a better Bureau of Standards that you could define in a mission statement, justify with cost-benefit arguments, and manage into existence. It could be a star in the country's institutional firmament.

The Soul of a Laboratory

Laboratories do have souls that are expressed in their intellectual traditions, their style, their ambience, their approach to life. I imagine the souls of human beings are intact from some indefinable early moment in life, but they do not become fully expressed until maturity. So it is with laboratories.

At the same time, the soul of a laboratory is a fragile thing. Long after it is withered due to either abuse or neglect, an institution — like the frog legs in the biology laboratory — continues to twitch its customary twitchings. Outsiders often can't tell the difference for a long time, but people in the laboratory can feel it in their bones.

Thus, the simple existence of national laboratories as a component of our national technical life is a precious asset — no less an asset than the great universities, our great industrial laboratories, and the extraordinary diversity of individuals, small companies and others who make up the vibrant national technical scene.

Of course, none of that tells us how many laboratories we need, how big they ought to be, or, indeed, what varieties of styles, talents, goals and traditions are needed. Nor does it tell us what their missions should be, and that is a legitimate subject for debate and decision.

The Changed National Environment

That debate hinges on one's view of the changed environment for the nation, against which we must judge the appropriateness of our national technological strategy

We face a national emergency, best expressed by looking at the stagnant growth of productivity in the United States compared to

our principal competitors and, indeed, some nations we never thought of as competitors before.

The consequences to our national standard of living of persistence in this stagnation are direct and predictable. Indeed, the evidence is already at hand, for U.S. per-capita-income now stands ninth in international rankings.

There is a major debate going on, which will be a focus of next year's Presidential election, under the rubric of "industrial policy."

That two-word cliche has been defined in the current political parlance to separate those who advocate it — and who are presumed to be in favor of a direct Federal role in trying to make U.S. industry more competitive by subsidizing its research, allocating its capital, or behaving in other interventionist ways ... versus those who are opposed to an "industrial policy," and by that mean they believe market forces are the best and most efficacious mechanism for allocating technological resources for economic purposes.

I think those characterizations are too simplistic. It would be enormously helpful if there could be a consensus in the nation on the value of improving the soundness of our technical muscle, throughout our institutions, much as we need to improve the soundness of our physical infrastructure.

Unless we increase our productivity and our competitiveness as a nation, there is simply not enough money to pay for the defenses required to fulfill our international responsibilities or to rebuild our crumbling infrastructure of roads, bridges, tunnels, harbors, airports, dams, sewers and water systems. Nor will we find the money to write off the outdated manufacturing facilities of American industry that make the lag in productivity growth a self-fulfilling prophesy.

Science, technology and better management are the keys to solving this long-term problem.

Sources of U.S. Science and Technology

The science must come from whatever institutions are in the strongest positions to provide it, for the migration of scientific knowledge into useful technology takes place through the marketplace of ideas in which all research institutions participate as equals.

A substantial part of our science has been arranged, as a matter of public policy, to come from our universities, for our young people — even those aiming at a career in production engineering, for example — must understand what creative science is all about, and must have tasted it and met people who do it.

The technology with which industry must be competitive will have to come predominantly from the industry itself.

To compete, you have to move too fast to depend on trickle-down from others. More importantly, to be competitive, technologies must be generated under the heavy discipline of day-to-day reassessments of both market demands and permissive costs. Yet, you must understand that when I use the word technology, I refer to the tooling and processes, skills and experience, that, taken together, permit the production of competitive goods and services.

The Creation of New Capabilities

Lying between that kind of technology and scientific research, there is a very large and vitally important middle-ground of tools, knowledge and training in areas of challenging intellectual interest, of strong dependence on leading edge science, and of direct usefulness to industrial technology.

Who does this kind of work? First of all, engineers who are working at pushing forward the state of the art of the capabilities of their trade do. So do scientists who have a dream or an objective in mind that requires the creation of a capability that doesn't exist.

That capability must be the capability to do something, but the "something" doesn't have to be a commercial product or a weapons system. It can just as well be the superconducting magnets for a new accelerator which drives the creation of new systems of engineered materials. Or, it can be a set of mathematical algorithms that would permit the efficient utilization of a 256-way multiprocessor for the computation of solutions to the hydrodynamic equations in three dimensions.

The point is, the object of the dream must be real and not fictional. There must be some hope of attaining it — indeed, a quest for personal satisfaction that comes from the possibility of attaining it.

Scientists and engineers in national laboratories require compelling goals if they are to do this kind of demanding, organized research that pushes forward the art of the possible.

National Laboratories and Economic Development

Let me explore for a minute the concept — which provides much of the focus of the Packard report — that the national laboratories could beneficially turn a significant part of their attention to work that would be of economic value in the productivity and competitiveness race.

We all know how *not* to do this job. For we can look at national laboratories in a number of other countries whose governments long ago decided that the institutions created initially for military and space work should be turned to the task of industrial and economic development. The record is a long record of failure, although there have been a few conspicuous exceptions.

The fundamental dilemma is that a government-funded laboratory, if it does not have the responsibility for carrying its work through to the end user, is very unlikely to exercise sufficient discipline, good taste, and willingness to admit failure to be successful in endeavors tested by market forces.

Indeed, the willingness to face failure, and face it quickly, is a peculiar hallmark of well-managed industrial laboratories and is almost denied the national laboratories — not because their scientists and engineers don't have the courage, but because Government sponsorship with public funds makes the penalty for failure unacceptable to their sponsors.

And yet, the national laboratories have just the skills that, in many cases, could address some very important base technology issues. How could this apparent contradiction be addressed?

I believe the answer may lie in two areas: First, compelling, technology-stretching Federal missions; and second, a significant — even major — entry by the national laboratories into education at the post-terminal professional degree level.

Technology-Stretching Federal Missions

On the first point, two things need to be accomplished.

1. The labs have proven they can do objectives-driven interdisciplinary work; they must prove they can redeploy their skills more agilely than universities. To this end, the Congress should give the Director of the Office of Science and Technology Policy the authority to redeploy a percentage — say 20 percent — of each of a half-dozen selected national labs on problems of Presidential urgency, with only the restriction that Congressional authorization and appropriations approval will be obtained before the end of three years' work on these projects.

This scheme has worked well in France, and I think it should be tried here. It would give the national laboratories the personality, if you like, of a central laboratory in a large corporation. It would enable them to put research in place soon enough to have a well-defined body of needed knowledge available when one of the sponsoring agency's programs suddenly develops a problem.

2. The missions of the national laboratories should be focused not only on the end objective and purpose as normally defined by their sponsoring agency, but should include extension of the base technologies — or, to describe it differently, the organized body of practical knowledge on which the achievement of the agency's long-range national objectives depends. After all, achievement of the agency mission is going to depend on both the national laboratories and on industrial contractors, implementers and others, all of whom need that base of knowledge.

The national laboratories should not attempt to compete with universities, although they may be partners with universities in providing facilities that the universities cannot have. Nor should they compete with industry, although partnerships there offer great promise for expansion.

Entry into Professional Education

My second suggestion is that national laboratories be encouraged to take a formal role in post-terminal, professional degree education. I believe this because the competitiveness of industry depends essentially on the skill and experience of its people.

To be competitive, one must move so quickly that the capability must already exist within the enterprise to take advantage of the technical knowledge available, from the outside and the inside, and go to work in the most rapid fashion possible.

There is a lot of hand-wringing about the fact that the Japanese — and, to some extent, the Europeans — sometimes do a better job of exploiting the scientific riches of our country than do our own companies.

That may be true, but the remedy sometimes proposed is worse than the disease: namely, to force the universities — or, for that matter, national laboratories — to become product development or process development laboratories for industry. That is the path to the destruction of science and the frustration of industry.

Instead, the responsibility must be placed squarely on industry to acquire the kind of people, and set them up in the kind of laboratories that enable them to reach out and access what's going on in our universities and national laboratories.

The universities are, indeed, the meeting ground for most of this information exchange, and they are designed to accomplish that. After all, their mission is the generation of knowledge and its transmission to the new generation of scientists and engineers. They do this, not by writing textbooks and handing them to their students, but by letting the students participate in the excitement of science.

Limitations of University Research

The trouble is, the universities seem constitutionally incapable of doing interdisciplinary research. Their engineering schools have been both uninterested and unsupported in broadening their missions to the kind of technological capabilities that would exercise the greatest leverage on industrial productivity.

They are interested now in the new manufacturing technologies, in systems engineering, and in teaching development engineers how to design something so that it's manufacturable with good quality and low cost. That is a new area they need to get into very rapidly

On the other hand, there are many people who are skeptical about how far universities can really be expected to go in setting up semiconductor pilot lines, in learning how to make useful contributions to magnetic storage technology, to exploring the process side of bioengineering and the new genetics technologies. And yet, there is a very great need in those areas to supplement what goes on in industry

There is a new vitality in the relationship between universities and industry. Indeed, it's moving so fast that almost none of the studies on the subject — including the one the Science Board did last year — have anything like up-to-date figures. The mechanisms that are coming into place permit industry to know what's going on in universities, and university scientists to find out what's exciting in industry and what people in industry need to know.

Those mechanisms are varied and increasingly impressive. IBM, for example, has in the last three years put into place over 430 separate research projects with 160 universities — 280 of which are current. We are investing some $75 million a year in this activity, and that is in addition to what we do in educational philanthropy.

And yet, there is still a set of limitations in the university research scene that leave a major gap unfilled Let me describe that in the following way

A History of Unfilled Needs

Discoveries in basic science made in universities — or, for that matter, in national laboratories — do have the capability to trigger whole new industries. They have done so in the computer field, they will undoubtedly do so in molecular biology. But when an industry takes off, it develops its own technology. If the discovery is sufficiently radical, in all likelihood the technology developed in the industry does not have its counterpart in the disciplinary structure of the university — either in science or in engineering.

Thus, the thousands of people who worked as computer scientists in IBM before the System/360 was announced in 1964 were educated as physicists or mathematicians or engineers. The new-hires learned their computer science as apprentices, because the first degree in computer science was not awarded until 1963.

In the late sixties and early seventies, we became completely dependent on integrated circuit technology. We were early pioneers in the field, but the people we hired were solid state physicists, metallurgists and others. They learned integrated circuit technology as apprentices, for the first Ph.D.s in LSI were awarded in about 1971.

The same thing is true in magnetic recording technology — an area whose revenues are so great that the disk file companies in the Santa Clara Valley of California alone would justify referring to it not as Silicon Valley but as Iron Oxide Valley.

And yet, except for a small program at Carnegie-Mellon University, there is no engineering school doing a graduate research program in magnetic recording engineering on the basis of which our industry might have some hope of being sure we stay ahead of the advanced work now going on in Japan.

Several companies recently joined with IBM to put up some millions of dollars to create such a program at the University of California, San Diego. The Science Foundation's engineering program will probably also help, but it will be the mid-eighties before the first Ph.D.s in this technology that supports a $7-8 billion industry are awarded.

The Perils of Apprentice Education

Now, an apprentice to a master bootmaker can learn how to make the best boots in the world. But when the master dies, or if an unexpected glitch occurs in the boot-making, the apprentice has no base of fundamental scientific knowledge to fall back on.

To base one's technology on apprentice education is a risk a technologically competitive company cannot afford to take — especially if it wants to be the world leader. In our case, we simply must help the universities modernize their capability as a matter of our own future competitiveness.

Upgrading University Efforts in Technology

The problem is that the technologies that industry is likely to depend upon most heavily are those which require interdisciplinary, coordinated work to pursue. An obvious example is the materials field but there are others, including many in which the national laboratories have great capability.

There is an important need here, not only for the industry efforts — from electronics to pharmaceuticals — to bring university capabilities up to a level where they can make a contribution, but also to look for new partners who are more accustomed to working in that middle ground between industrial technology and pure research.

There are a number of interesting new mechanisms in the relationship between industry and universities — for example, the Semiconductor Research Cooperative. This organization is a multi-company funded, not-for-profit activity, with the money invested primarily in universities but, again, it is devoted to areas of exploratory technology and advanced engineering of the sort I have been describing

There are many, however, who doubt the wisdom or the viability of investing university effort in complex technology areas like large-scale integrated circuits. The capital equipment requirements are very great, and a single injection of funding will not be sufficient. Obsolescence times for the equipment are as short as three years.

Can the universities sustain this kind of capital-intensive activity in the more applied end of the research spectrum? The optimists would point to the new NSF policies in engineering and to the remarkable success in fund-raising from private sources of organizations like the Stanford Integrated Circuits Laboratory. The pessimists would point to the traditional difficulties of universities in multidisciplinary, relatively applied work, in competition with intense efforts in industry.

Even the Semiconductor Research Cooperative, in the course of trying to develop a project to build a four-million-bit random access memory chip, is now exploring the idea that a national laboratory with semiconductor capability might carry out such a project, rather than a university.

A Proper Role for National Laboratories

This brings me to my own view of a proper role for national laboratories in the area of technology to support economic development.

A national laboratory should, in the first instance, support the mission of its sponsoring agency This goes without saying. That mission must define the technical scope and, by implication, the technical personality of the laboratory Within these areas of expertise, one would expect the national laboratory to make major contributions to basic knowledge

Since national laboratories will usually have an important technological component to their mission, and since they should take advantage of their special capabilities for specialized equipment, technological resources and team activity, one would expect that the basic knowledge which such a laboratory contributes would often contain extremely valuable technological components. Experimental science and very sophisticated engineering would generally be heavy thrusts.

Even if no additional steps were taken to enhance the economic utility of such work, it would make an important contribution. But I believe that two mechanisms are needed if economic value is to be significantly enhanced

Two Mechanisms Needed

The first requirement is to put the laboratory personnel in good contact with their peers in leading edge companies. This can be done by creating a climate for joint research, by a program of off-site sabbaticals going both ways, by an appropriate group of advisory committees and other means of information exchange.

The second and most important element that would make the system work would be for the laboratories to engage in organized educational activity at the post-doctoral, professional degree level.

By post-doctoral, I mean all the way to retirement, not just immediately after the Ph.D , for industry faces a major problem in assuring that its technical community remains educated at the cutting edge. We spend immense amounts of money in IBM on education Our people are told when they join the company that they will be students for most of their careers. Yet, we continue to look for dynamic and exciting institutions outside the company that can provide that mid-career refreshment education

The interests of industry will always be enhanced if a primary benefit of the collaboration is the first-hand acquisition of skills by people who are either on assignment or who may anticipate employment in industry

One might raise the question whether or not this kind of training activity is competitive with the universities. Perhaps to some extent it is, but I would make the principal demarcation between degree-seeking education — the primary province of the university — versus the gaining of technical experience without the award of formal degrees by individuals either taking a year or two from industry or, possibly, in transition from a national laboratory to industry.

An Example from the Field of Computing

Let me take a specific example in the field of computers. There is a resurgence of interest in large-scale computing, both for scientific and engineering applications and commercial interactive computing.

The demand for computing by large industrial users is now skyrocketing. We see a 60 percent annual growth in compute power requirements for commercial applications — mostly for database/data communications and end user interactive applications. Within the latter segment, engineering applications are driving a 70 percent growth rate, largely as the result of automated design simulation and test

There is also an emerging consensus that large-scale computation may have greater significance for the progress of science than the productivity aid it has always been. Mathematicians, physicists and life scientists are beginning to demonstrate that computation can produce new knowledge — becoming the scientist's collaborator, not just a tool for processing data and solving known equations

If a national laboratory is dedicated to ambitious scientific and technological goals, and devotes itself to developing more advanced tools for accomplishing both engineering and scientific tasks, it cannot avoid a major focus on computer applications research.

This is particularly so at a time there is so much interest in new architectures, such as n-way multiprocessors. Whereas the central compute power requirements of large organizations are growing at 60 percent a year, the semiconductor industry produces about 25 percent per year cost-performance improvement and the industry is growing at only 15 percent a year. That is not bad, but 15 and 25 are not 60, thus forcing the future into a multiprocessor environment and raising some major architectural challenges.

All our experience, from the disappointing ILIAC IV to the present, tells us that hardware architecture is an interesting area for engineering research but, to paraphrase an old saying, "The proof of the pudding is in the programming."

There is no doubt that n-way engines can be reasonably efficient in special applications. IBM's Yorktown Simulation Engine — architected as a 256-way, crossbar switch connected multiprocessor — is probably the largest multiprocessor in practical use that efficiently loads all its engines. Its use, however, is for logic simulation in the design of very large computers — a very specialized application. To be generally useful, such a machine must be able to meet two tests if the economies of multiprocessing are to be realized:

1. It must be easily programmable in an appropriate high level language.

2. It must be able to keep all its processors busy, both in time and in space. That means the ratio of sustained to peak performance must not be too small, and all of the engines must participate in the system's work

Little can be learned by study of the hardware alone It will take a lot of talent, time and effort to develop the system software that both runs the hardware efficiently and supports the end user effectively.

The computer industry long ago discovered that our best systems software is usually developed in collaboration with one of our major customers. This will also be true for the new generation of high performance machines — both the n-way multiprocessors and high-speed uniprocessors with vector instructions — especially so since the real performance breakthroughs are likely to come from mathematicians who can match powerful new algorithms to the system structure and the high level language.

I would welcome a major focus of national laboratory interest in this area if that interest is focused on long-term, real mission objectives of the laboratory so that the test of end user efficacy is never absent as a driver of the work.

The universities can contribute a lot to hardware and software research. Indeed, there is a ferment in computer science departments lashing microprocessors together, and it is there, and in industry, where most of the research effort is today. But the scale of effort required to subject new system concepts to the discipline of real problems is far beyond the universities, and we can't cover them all. Today, our main partners in work of this sort are places like General Motors Research, Boeing, and the large oil company laboratories.

To the extent the national laboratories make a major contribution to the advancement of engineering computation, and accept the responsibility to document and communicate this progress, they will become very attractive places for industrial sabbaticals, cooperative projects, and training programs for industry.

It is not just the computer industry that stands to benefit but that industry's technologically sophisticated customers. They are the ones who are even more likely to want to take advantage of such opportunities.

I believe analogous examples can be found in materials engineering and many other fields.

Perhaps, in that way, national laboratories can expand the contribution they are already making to productivity. I am sure it will require a fundamental change in both the policies and priorities in the Federal agencies that sponsor the laboratories to undertake this kind of activity on a large scale.

It will doubtless take a change of attitude in industry, which must increasingly appreciate that hiring someone out of school means that they have made, in today's full employment society, a minimum $1 million investment in that person's future usefulness.

It will also, no doubt, shift the focus of some of the laboratories in what might look like a more applied, or more engineering, direction. But the technical challenge can become even greater, and the professional satisfaction in the work even greater.

We need a fuller appreciation, not only by the scientific community but the people in Washington and elsewhere who put up the money, that our technical effort must cover the full spectrum from basic research through product development and the delivery of solutions to problems; and, importantly, that the main institutions of society have got to support this effort rather more effectively.

It would be a step in the right direction if at least the positive parts of the Packard report get implemented this time. It would be even more useful if the rhetoric over industrial policy gave way to a dialog more likely to build widespread understanding and support by the main institutions of our society for the nation's overall technical effort.

Mr. WALGREN. Thank you, Dr. Branscomb.

Let me just clear up that last sentence for my understanding. You raised the thought of a microdepartment of science which would look at those three agencies?

Dr. BRANSCOMB. Let me try to state that more clearly. The task of creating a full-fledged Department of Science worthy of being a cabinet department is a major, very complicated issue that you've discussed before, and we can talk about later. We don't have time today.

My suggestion is that one make a start in the discussion by discussing a much more limited question which came up in connection with the proposal for a Department of International Trade and Industry, which was a limited question of should the National Bureau of Standards better be associated with NSF or be associated with the rest of the Department of Commerce.

I can't give you a simple answer to that, but I think the study of that question would reveal the issues and would sharpen the questions that need to be understood. For the arguments—the perspectives that are taken now by the constituency of the Science Foundation and the constituency of the Department of Commerce, we don't admit of a solution.

And my hope would be that by discussion of that role and mission issue, we would either persuade the Department of Commerce that it must extend its view on its economic role to include the bolstering of the quantitative basis for science in this country, and that it should have activities that go outside the narrow standards mission of the Bureau of Standards.

Or, on the other hand, that we might persuade the National Science Foundation that it has a larger role too than simply the support of university science; that it must also attend to the infrastructure for science and technology in this country.

Mr. RITTER. Will the chairman yield?

Mr. WALGREN. Yes; I'd be happy to yield.

Mr. RITTER. As one who is interested in creating a situation whereby the National Bureau of Standards can flourish, I would be cautious about a National Science Foundation link. The National Science Foundation has a fairly defined mission, and I think that's why it's been reasonably successful. It's mission has never really become controversial; the mission is that of basic research, the arm of funding for the universities largely.

And NBS, of course, has such a different type of mission, that to put it under or with such a totally different operation could be asking for more problems than we already have.

Dr. BRANSCOMB. I'm not advocating the switch, because I agree with you that that is a problem, that is an issue. It's a separate issue that we're not here today to discuss; namely, to what extent should the NSF restrict itself, its mission, to fundamental research in universities versus a broader role in support of the scientific and technical strength of the Nation.

But I would submit that the organic act for the National Science Foundation is at least capable of interpretation, as saying that it does have that task to support the scientific and technical vitality of the Nation and the physical sciences.

My point is that the present situation, where the Bureau of Standards is in the Department of Commerce, falls terribly short of the vision which you so eloquently expressed before the break. I feel that we have all observed this relationship between the Bureau of Standards and the Commerce Department for many, many years. I have observed it during my entire professional career which started at the Bureau of Standards in 1951, and I feel it needs some structural fixing.

The symptoms that I read from the Department of Commerce—it advocated that it should be a Department of International Trade and Industry and it requested in that context that it should be relieved of the responsibilities of the National Bureau of Standards—suggests to me that the Department is at least of two minds about the essential nature of the Bureau of Standards in its mission.

Mr. **Ritter**. Thank you, Mr. Chairman.

Mr. **Walgren**. Thank you, Mr. Ritter. Well, thank you very much for that statement, and we'll come back. Let's go then to Dr. Ancker-Johnson.

STATEMENT OF DR. BETSY ANCKER-JOHNSON, VICE PRESIDENT, GENERAL MOTORS ENVIRONMENTAL ACTIVITIES STAFF

Dr. **Ancker-Johnson**. Thank you, Mr. Chairman and members of the subcommittee. I appreciate this opportunity to present views, especially as a former Assistant Secretary in charge of the Bureau, among other agencies, about the NBS and its ability to provide appropriate services to U.S. industry now and in the foreseeable future.

I want to compliment the committee on the thoroughness of these hearings. You've been a very energetic committee for many years.

The Bureau's mission and activities are clearly too multifaceted even for me to address in my formal statement, and certainly in this abbreviation. I would like to concentrate on just one aspect, its relationship to industry.

The economic well being of our Nation and our standard of living does depend on how skillfully U.S. industry commercializes technology. As a result, the United States increases the ante each year for research to assure a ready supply of new and improved technology. And yet, this industry has the sole responsibility for taking U.S. technology to the marketplace. But sometimes our U.S. science and technology policies seem blind to the critical role which NBS plays in commercializing the technology that results from the large annual investment that we do make in R&D.

It's perfectly obvious to all of us that the United States has lost its leadership in the low technology areas of industry. Just recently the American Electronics Association pointed out that last year we were also $7 billion in trade deficit with respect to sophisticated electronic technology. That is a cause of enormous concern.

As what I'd like to think of as the Central Research Laboratory for the United States, NBS plays an absolutely critical role in the physical measurements necessary for our products and processes. It's absolutely essential for the commercialization of the technology which we are often creating but not utilizing adequately in this country. Just the standardization efforts of some 450 scientists and engineers serving on perhaps 1,000 committees for generating these product and process standards are absolutely crucial to the furtherment of our economic well-being in this country.

I'd just like to illustrate the ubiquitous influence of NBS on U.S. industry by mentioning some areas of technology which are of importance to my industry, the automobile industry, which NBS has significantly influenced.

NBS research has provided and continues to provide critical know-how and measurements for the processing of crude oil, the energy content of fuels, the lubrication of oils, the efficiency of combustion engines, the properties of ores and metals, the fabrication of glass, the production of rubber products, the durability of paints, the characterization of textiles, the performance of tires, the safety of passenger restraints, taxonomy of colors, exhaust products, electromagnetic interference, electroplating, surface smoothness, corrosion, and so on.

The incubations of such technologies in NBS laboratories at critical stages of their development has provided a significant boost, and continues to provide a significant boost, to the U.S. economy. Such NBS research is always performed in collaboration with the user companies, and is motivated only by self interest of all the participants. Such collaboration is the ultimate in technology transfer.

NBS supplies U.S. industry about 1,000 different certified samples for use in research, in buying and selling raw materials and finished materials, and for controlling the various fabrication processes. The automotive industry, for example, does not leave the quality of windshields, of body frames, sheet metal, electronic materials, tires, pollution controls and gas mileage indicators, et cetera, to chance. We rather depend very heavily on the standard reference materials and certified samples supplied by the NBS.

I'd like in particular to tell you about a specific activity that the National Bureau of Standards has been active in, and in fact played a crucial role in, which is of very great importance to the future of the country. It's called the manufacturing automation protocol.

General Motors, my company, has entered into a formal agreement with the National Bureau of Standards to demonstrate the compatibility of a number of vendor's computer equipment, many different makes and types, with the objective of being able to network these equipments on the factory floor and office workplace as well as remote stations.

The future of our competitiveness as a country depends very highly on this work. We need to be able to link computers that are controlling robots in the assembly process to computers that are ordering the raw materials, to those building these devices or equipment, whatever it may be that's being assembled in the factory; linking to those as well that are placing the orders from customers, linking to the inventory records and to computers keeping track of payroll, and so on and so on, in a highly complex network system located in many remote locations—a gigantic and complex system.

Without NBS it would not have been possible in July of last year for 7 vendors to network their various computers, to demonstrate the first step in this process, and next month for 17 vendors to link their equipment that will be showing and demonstrating the control of robots, their linking to office computers, and even remote stations.

GM is already using this technology and developed jointly with the National Bureau of Standards in, for example, our newest assembly plant in Detroit. NBS will in the future continue to play a very leading role in this effort by certifying that the test software actually does reflect the standards, in other words, that this complicated system does perform according to expectations and requirements.

I'm going to defer to Dr. Slichter to talk about the appraisal system at the Bureau of Standards, but I can't help but say that the over 200 leading U.S. scientists and engineers who annually take part in a review of the NBS invariably give the Bureau high marks for performance and praise the Bureau's program, and bemoan the lack of adequate resources.

I listened very carefully to this group when I was Assistant Secretary, and I agree with the findings of my respected and prestigious peers. And I look forward to hearing what Dr. Slichter will say.

With that, let me turn to a last item that I want to call to your attention. I'm gratified that the administration is addressing the threat of foreign competition through new policy directives aimed at increasing the rate of commercialization of new products and processes created by the some $55 billion Federal investment in research and development.

Part of this effort is properly directed to reallocating funding toward basic research where commercial incentives are weak and away from development and demonstration of commercial technologies which are more appropriately undertaken with private funding.

The administration also recognizes the need to involve Federal research organizations, such as NBS, in helping to bring new technology to the marketplace. By combining appropriate authorities and incentives, that are now lacking, with the laboratories firsthand knowledge of technology, the Congress can ensure progress toward this goal.

You will recall that the administration's support and implementation of laws giving universities and small businesses ownership of technology resulting from Federal support stimulated, what I think can be fairly called, a veritable explosion of private sector investment in the commercialization of such technologies.

The advantage to be achieved by extending this approach to all federally funded research laboratories can no longer be dismissed as just speculative. S. 64 and S. 65, and now H.R. 695, are directed to bringing this policy to both Federally managed research laboratories and contractor research laboratories not covered by the university and small business law.

S. 65 and H.R. 695 are aimed specifically at permitting Federal laboratories, such as NBS, to enter into cooperative research and development arrangements within their mission assignment, with the private sector.

Under these arrangements the laboratory may accept funds, services, and property from collaborating parties, and provide services and use of facilities in exchange; second, they can grant or agree to grant in advance to a collaborating party patent licenses or assignments, or options thereto, in any invention made by the laboratory; and third, accept royalty payments for laboratory use including sharing with laboratory inventors. That latter is really quite important.

These authorities and incentives roughly duplicate those that have triggered the expansion of university and industry collaboration, particularly in the biotechnology area.

In conclusion, let me just say that, in spite of the dramatic national budget crunch, we must consider the economic benefits which accrue from investments in NBS. As a matter of national self-interest, the United States invests large sums in the creation of technology, yet we seem to be lagging behind our international competitors even in the use of the technology that we create.

NBS is the only Federal agency dedicated to facilitating the use of technology for national economic benefits rather than for advancement of a specific mission. NBS is most effective in catalyzing industrial efforts for removing technical barriers to the commercialization of technology.

While it may not be politically wise to recommend additional resources for mature agencies, it would be in the best interest of the Nation, I believe, in the case of NBS to provide additional resources as required to improve further the U.S. use of technology.

Thank you, Mr. Chairman.

[The prepared statement of Dr. Ancker-Johnson follows:]

STATEMENT OF DR. BETSY ANCKER-JOHNSON
VICE PRESIDENT, GENERAL MOTORS CORPORATION
BEFORE THE SUBCOMMITTEE ON SCIENCE, RESEARCH & TECHNOLOGY
OF THE
COMMITTEE ON SCIENCE & TECHNOLOGY
U.S. HOUSE OF REPRESENTATIVES
ON THE FUTURE ROLE AND MISSION OF THE NATIONAL BUREAU OF STANDARDS

OCTOBER 1, 1985

Mr. Chairman and Members of the Subcommittee:
I appreciate this opportunity to present my views about the National Bureau of Standards and its ability to provide appropriate services to U.S. industry now and in the foreseeable future.

Let me compliment you on the thoroughness of these hearings on the state of the National Bureau of Standards. My first opinion of the National Bureau of Standards was formed when I was a practicing bench scientist. It matured during the period I administered the affairs of NBS as Assistant Secretary of Commerce for Science and Technology, and it continues to mature as I view the Bureau once again from my vantage point back in U.S. industry. The Bureau's mission and activities are too multifaceted to be addressed in my statement today. I will therefore limit my views to only one aspect of the NBS, i.e., industrial relations. I pick industrial relations because: (1) you are already well aware of the profound influence of NBS on science, engineering, Government, health care, public safety and most other high-techology concerns of U.S. society; and (2) I consider this a serious blind spot of U.S. science and technology policy.

The economic well-being of our Nation and the standard of living of our citizens depends on how skillfully U.S. industry commercializes technology. As a result, the U.S. increases the ante each year for research to assure a ready supply of new and improved technology. U.S. industry has sole responsibility for taking U.S. technology to the marketplace. Unfortunately, U.S. science and technology policy seems blind to the critical role which NBS plays in commercializing the technology which results from the large annual U.S. investment in R&D.

Technological Role of U.S. Industry

In the U.S. economy, industry is expected to create, make and sell safe, reliable, useful products and services at a profit. Each industrial firm must find a market niche in which to outperform competition at home and abroad. Foreign competition has increased at an alarming rate in recent years, particularly since about 1965, and will intensify rather than subside over the 15 year period being considered by this Committee. We have long since lost our market position in many of the so-called low-tech product areas. We thought that we could maintain our markets in high-tech products and services. This assumption appears to be in considerable doubt. Nationally supported industrial ventures from abroad have learned how to target and penetrate markets which the U.S. had expected to retain. According to a report by the American Electronics Association, we suffered a $7.0 billion trade deficit in high-tech electronic products this past year. The U.S. economy and well-being depend on the success of U.S. industrial firms and these firms rely on NBS for some critical services.

The NBS Role

NBS is the Nation's Central Research Laboratory for the measurement of physical phenomena and systems. It is the keeper of the U.S. measurement system in the same sense that the Treasury Department and Federal Reserve Board control the U.S. monetary system. Credible measurements are as vital to U.S. industry as a sound dollar is to the U.S. economy. With tongue only partially in cheek, I point out that the U.S. mint puts "in God we trust" on U.S. coins while U.S. industry only has to put "traceable to NBS" on its measurements to gain immediate acceptance. Measurements are the forerunners of modern industrial innovation, are essential for production, and are the language of exchange in the marketplace.

To be the kind of Central Research Laboratory needed by U.S. industry, NBS must be one of the premier laboratories of the world. Industry recognizes the quality of NBS science and engineering by annually sponsoring the visits of thousands of scientists and engineers to the NBS laboratories to gain know-how and inspiration.

Industrial Expectations

One of the best kept secrets in the U.S. is the extent to which industry-NBS interactions permeate the industrial process. NBS assists in each phase of this process from innovation to production to sales and use. Through research in the measurement sciences, for example, NBS makes major contributions to industrial innovation. This year the Industrial Research Magazine granted seven IR 100 Awards to NBS for innovation, more than to any other laboratory, industrial or governmental.

To illustrate the ubiquitous influence of NBS on U.S. industry, I will mention a few areas of technology of importance to my industry which NBS influenced significantly. NBS research provided critical know-how and measurements for the processing of crude oil, the energy content of fuels, the lubrication of oils, the efficiency of combustion engines, the properties of ores and metals, the fabrication of glass, the production of rubber products, the durability of paints, the characterization of textiles, the performance of tires, the safety of passenger restraints, the taxonomy of colors, exhaust products, electro-magnetic interference, electroplating, surface smoothness, and corrosion. The incubation of such technologies in NBS laboratories at critical stages of their development provided a significant boost to the U.S. economy. Such NBS research is always performed in collaboration with the user companies and is motivated only by self interest of all participants. Such collaboration is the ultimate in technology transfer.

NBS supplies U.S. industry about 1,000 different certified samples for use in research, in buying and selling raw and finished materials, and for controlling the various fabrication processes. The automotive industry, for example, does not leave the quality of windshields, body frames, sheet metal, electronic materials, tires, pollution controls and gas mileage indicators, etc., to chance. Twenty years ago General Motors made a survey of its use of NBS Standard Reference Materials. It found that our research laboratories alone used 61 percent of the Standard Reference Materials offered by NBS at that time and 75 percent of the 380 samples certified for chemical composition. The survey indicated a need for NBS to increase the number of different samples by about 50 percent. It is pertinent to note that the operating Divisions of General Motors did not contribute to these statistics but did indicate a need for Standard Reference Materials. Today, General Motors continues to be a major user of Standard Reference Materials. Supplying Standard Reference Materials is but one of the many ways by which NBS helps U.S. industry keep measurements in their laboratories and product lines under control.

U.S. industry expects NBS to play an omnipresent third-party role in the marketplace by providing objectivity and sound technological judgment whenever and wherever needed. We in industry have a cliche to the effect that we have accomplished nothing until a useful product or service is sold. Performance in the marketplace is our moment of truth. You often hear people from industry say that they want a "level playing field." In its broadest sense, this only means that industry wants a fair chance in the marketplace. About 450 Bureau scientists and engineers sit on about 1,000 standardization committees which generate the product and process standards which are the rules of the domestic and international marketplace. U.S. industry is served well when a call to NBS will identify any one of the 250,000 national and international product and process standards. NBS keeps industry informed on the state of the international GATT proceedings. NBS will represent specific interests of an industrial firm in GATT proceedings. NBS manages a National Voluntary Accreditation Program which gives the U.S. product and services credibility in both the domestic and international marketplace. NBS provides State weights and measures officials with the measurement methodology and standards, training and advice needed to assure honest weight for multi-billions dollar trade in the U.S. domestic marketplace. In these and many similar ways, NBS removes or prevents barriers to trade.

NBS is a ready source of generic technology and overt technical intelligence. Bench scientists and engineers in industry have a long history of close collaboration with their peers in the NBS. Many of the NBS Divisions are in a real sense the technical mecca of their discipline. The value of readily available NBS know-how and facilities is becoming better recognized by industrial managers. It is significant that the number of Industrial Research Associates sponsored in the NBS laboratories by U.S. industry more than doubled in the last five years. This means that the leaders of U.S.

industry believed that more than 200 of their better engineers and scientists would be more useful to their respective companies stationed in the NBS laboratories. Industry has sent millions in hardware and instrumentation to accompany their Research Associates.

NBS catalyzes the solution of sophisticated, complex industry-wide technical problems by sponsoring ad-hoc working arrangements of the various interested small and large size companies. My company, General Motors, has a formal agreement with NBS to demonstrate the compatibility of various makes of computer equipment which meet the new international network standards. The technology involved is an integral part of the factory of the future. In support of this technology, NBS has developed testing methods and a laboratory necessary to verify the performance and ability of different computer systems to meet the network standards; it is also holding workshops attended by representatives of more than 100 companies and organizations to transfer this technology to and among vendors and users. At present, seven companies are running the NBS tests for an industrial network designed for use in factory computer systems at a GM site. These seven companies are Allen Bradley, Concord Data Systems, Digital Equipment Corporation, Gould Modicon, Hewlett-Packard Company, IBM, and Motorola. If these arrangements sound intertwined and complex, it is because they are by necessity. NBS is a key component of each circle of collaboration. The technology simply would not evolve so well or so quickly without NBS involvement.

U.S. industries are not the only beneficiaries of the NBS forums. Each of us can be pleased that the American Dental Association and the American Society of Pathologists discovered NBS years ago. Improvement in our dental care and clinical measurements over the years attest to the advantages from collaboration with NBS.

NBS has many well-proven means such as the Standard Reference Data and Standard Reference Materials, Research Associate, Guest Worker and Measurement Assurance Programs, workshops, conferences, standards-making and calibrations for transferring its know-how to U.S. industry; however, the individual bench scientist at NBS is undoubtedly the most effective source of transfer. They collaborate with their peers in industry as a way of life.

Performance Appraisal

Over 200 leading U.S. scientists and engineers carefully review and assess NBS, its professionals, facilities and programs each year. They invariably give the Bureau high marks for performance, praise the Bureau's programs and bemoan the lack of adequate resources. I agree with the findings of my respected and prestigious peers. I find NBS management to be scientifically competent, dedicated and sensitive to industrial concerns. The NBS scientific and engineering staff are highly respected by peers in industry and universities. In my judgment, those at NBS with whom I have worked—and I have worked with many —deserve their good reputations.

In addition, the scientific and engineering communities with which NBS scientists collaborate provide subtle but effective quality control. The Bureau's programmatic thrusts (Automated Manufacturing, Materials Processing, Chemical Engineering, High-Performance Semiconductors, and Bio-Technology) are on target. These technologies will limit or pace industrial competitiveness during the next 15 years and probably for the foreseeable future. Thanks to your Committee, modern computer facilities are coming on stream. The building of technical competence is proceeding, albeit at an unfortunately slow pace.

Policy Changes?

I am gratified that the Administration is addressing the threat of foreign competition through new policy directives aimed at increasing the rate of commercialization of new products and processes created by the 55 billion dollar Federal investment in research and development. Part of this effort is properly directed to reallocating funding toward basic research, where commercial incentives are weak, and away from development and demonstration of commercial technologies which are more appropriately undertaken with private funding. The Administration also recognizes the need to involve federal research organizations such as NBS in helping to bring new technology to the marketplace. By combining appropriate authorities and incentives that are now lacking with the laboratories' firsthand knowledge of technology, the Congress can insure progress towards this goal. You will recall that the Administration's support and implementation of laws giving universities and small businesses ownership of technology resulting from Federal support stimulated a veritable explosion of private sector investment in the commercialization of such technologies. The advantage to be achieved by extending this approach to all Federally-funded research laboratories can no longer be dismissed as speculative. S. 64 and S. 65 are directed to bringing this policy to both Federally managed research laboratories and contractor research laboratories not covered by the university and small business law.

S.65 is aimed specifically at permitting Federal laboratories such as NBS to enter into cooperative research and development arrangements within their mission assignment with the private sector. Under these arrangements the laboratory may:

1) accept funds, services and property from collaborating parties and provide services and use of facilities in exchange

2) grant or agree to grant in advance to a collaborating party patent licenses or assignments, or options thereto, in any invention made by the laboratory

3) accept royalty-payments for laboratory use including sharing with laboratory inventors

These authorities and incentives roughly duplicate those that have triggered the expansion of university collaboration with industry in the biotechnology area.

Budget and Programmatic Changes?

Second guessing NBS management is at best of marginal value. NBS management does its homework, knows its clientele and understands its mission. Managers, scientists and engineers from industry who assess NBS programs invariably applaud the NBS mix of programs and priorities.

An order of magnitude increase in the NBS budget might well prove a wise investment and in the long-term interest of the U.S. economy. However, I am not naive or gutsy enough to make such a proposal in the present budget environment. Indeed, as the Assistant Secretary responsible for NBS I was necessarily engaged in holding spending down while simultaneously trying to keep this premier national resource in good health.

In my view, the best interest of U.S. industry would be served if Congress would:

(1) Give NBS the resources to ratchet up competence building and facility modernization at least ten percent a year.

(2) Allow NBS to go forward with construction of the cold neutron facility. Since the NBS reactor was already designed to allow

the addition of a cold neutron source, installation of the source at NBS was a "steal" for the U.S. The construction of the cold neutron laboratory, which will allow many users from industry and academia to access the new source, will go a long way toward moving the U.S. to the forefront of materials research, a matter of great concern to the future competitiveness of our industry.

(3) Sponsor NBS in collaborating more actively with small business and in particular with the various existing regional development efforts.

(4) Encourage Bio-Technology Measurements at NBS.

(5) Expand NBS measurement services in support of industrial competitiveness and quality control.

(6) Encourage NBS collaboration with U.S. industry in materials science and engineering. (It appears that our aggressive trading partners are determined to grab the ceramics and composite market by being there first with the best.)

Given modest additional resources, NBS can make a difference. NBS knows how to collaborate with U.S. industry in the better use of science and technology. NBS has the necessary nucleus of trained manpower. NBS can attract and assimilate additional competent scientists and engineers. While it might face recruitment problems in some areas such as computer science and electrical engineering, NBS has a remarkable track record of performing its role through collaboration with industry and universities. Moreover, the opportunity to work at the forefront of science and engineering in the prestigious NBS environment still attracts men and women of exceptional quality even though the salaries may not always be competitive.

Closing Remarks

In spite of the dramatic national budget crunch, we must consider the economic benefits which accrue from investments in NBS. As a matter of National self-interest, the U.S. invests large sums in the creation of technology, yet we seem to be lagging behind our international competitors even in the use of the technology we create. NBS is the only Federal agency dedicated to facilitating the use of technology for national economic benefits, rather than for advancement of a specific mission. NBS is most effective in catalyzing industrial efforts for removing technical barriers to the commercialization of technology. While it may not be politically wise to recommend additional resources for mature agencies, it would be in the best interest of the Nation in the case of NBS to provide additional resources as required to further improve the U.S. use of technology.

BETSY ANCKER-JOHNSON

Dr. Betsy Ancker-Johnson is (since 1979) Vice President of General Motors Corporation in charge of Environmental Activities Staff. She is responsible for the emission control and safety of General Motors products and control of pullution generated by its plants. She also supervises activities related to fuel economy and international regulations.

From 1977 to 1979, she was Associate Laboratory Director for Physical Research with Argonne National Laboratory. From 1973 to 1977, she served as Assistant Secretary for Science and Technology, U.S. Department of Commerce where she was responsible for the National Bureau of Standards, Patent and Trademark Office, Office of Telecommunications, Office of Product Standards, National Technical Information Service, and Office of Environmental Affairs.

Dr. Ancker-Johnson was employed by the Boeing Company in several management positions from 1970 to 1973 and as a research specialist at its Scientific Research Laboratories from 1961 to 1970.

Other research assignments have included that of research physicist, University of California, Berkeley; senior physicist, General Telephone and Electronics Corporation; technical staff member, RCA David Sarnoff Laboratories; and visiting scientist, Bell Telephone Laboratories.

Dr. Ancker-Johnson received her bachelor of arts degree in physics from Wellesley College in 1949 with high honors and was graduated magna cum laude with a Ph.D. in physics from Tuebingen University, Germany, in 1953. Dr. Ancker-Johnson is the recipient of honorary doctor of science degrees from the Polytechnic Institute of New York, the University of Southern California, Berkeley, Trinity College and Alverno College; and an honorary doctor of law degree from Bates College.

Dr. Ancker-Johnson has written over 70 scientific papers and holds several patents in the fields of solid state physics, controlled thermonuclear fusion and microwave electronics. She is a member of the National Academy of Engineering and is a fellow of the American Physical Society, Institute of Electrical and Electronic Engineers, and the American Association for the Advancement of Science. Dr. Ancker-Johnson is also a member of the Stanford University School of Engineering Advisory Council, the Massachusetts Institute of Technology Corporation Visiting Committee, and the Board of Directors of General Mills.

April 1985

Mr. **Walgren**. Thank you, Dr. Ancker-Johnson.
Dr. Slichter?

STATEMENT OF DR. WILLIAM P. SLICHTER, EXECUTIVE DIRECTOR, RESEARCH, MATERIALS, SCIENCE AND ENGINEERING, AT&T, BELL LABORATORIES

Dr. **Slichter**. Thank you, Mr. Chairman. And thank you for inviting me to attend this meeting to speak to some views of the present activities and the future role of the Bureau of Standards. As an individual scientist, I date in my association with the Bureau about as far back as my good friend Lou Branscomb. I first came to the Bureau of Standards as a visitor to benefit from its wisdom back when it was on Van Ness Street in the District, and have followed with great enthusiasm and great value the work of the Bureau ever since.

Indeed, my special role today is that of the chairman of the assessment panels for the programs of the National Bureau of Standards, which serve under the authority of the National Research Council, and have since 1959 provided a continuing evaluation of the functions and operations of the Bureau, as you're well aware.

The fact that over the years some 2,500 engineers and scientists from all parts of industry and academe have welcomed the opportunity to serve on these panels, I think is considerable testimony to the importance that these people and the organizations with which they're attached view the work of the Bureau and the place that it holds in the scientific and technological life of the country.

You're aware, I'm sure, that the Board of Assessment has reported in the past that the Bureau is in very good health, and that is certainly true today in consequence of a performance with dedication, objectivity, a great deal of enthusiasm and assurance, despite the vicissitudes that we've talked about until now of budgets, and so on.

We, the assessment panel, have had opportunity to see these activities at close hand, and most of us have other opportunity to work with the people at the Bureau to know them very well indeed.

A point that the panel feels strongly about is that sustained support is essential to productivity in research. Continuity of funding is vital to avoid the ups and downs that beset funding activities in so many places. Nature plays enough ups and downs on investigators without their wanting to encumber their lives yet further with an uncertain future as to funding.

A comment was made that 30 years ago the organization had a severe attack upon its objectivity—an entirely wrongful attack. And not long ago the Bureau experienced a major reduction in the work force, which clearly had a damaging effect on morale. Those things clearly are in the past, but it is still a tight operation.

It's vital to remember that the pace of research in the world continues unabated. And the vigor of research in America is this country's best challenge against foreign industry. Since the Bureau of Standards was founded, the progress in metrology has been striking indeed, and Dr. Branscomb alluded to the manner in which the Director and his managers from time to time reassess and realign the responses of the Bureau to the changes in technology. And this is the way it should be.

The Bureau has received good—but I would have to say not extraordinary—attention from the administration and indeed the Congress in recent years for its research. The institution of a competence program, offering flexibility to the Director, was very important and has taken recent form, for example, in the work on biotechnology, which is an area in which scientific developments are occurring with almost explosive speed in this country.

The panel thinks it's important for the Bureau to be given strong incentive to think about the future. There are people with experience and depth who are capable of making long range plans for metrology and the associated disciplines, and they should be supported and encouraged to do this sort of thing.

The question of the role of research in measurement science has been discussed some today. I think the answer is that people in industry and commerce and academe intrinsically operate under a basic need for ever greater accuracy and greater precision in measured quantities. And research is the root to achieving that competence.

When a better standard of measurement is found, people will inevitably make use of it. And at the Bureau of Standards, the people responsible for this work are indeed at the leading edge of science and technology, and will remain so so long as they're encouraged to remain a part of the scientific community.

I think, in fact, some of the questions of the future of measurement and data in the Bureau center about a review from within as much as without of the competences of the Bureau in areas such as the provision of standards, reference materials, data compilations. And that the temptation for others from the outside to insert wisdom into this process is something that we need to regard with at least caution.

In contemplating the Bureau's future, I think we ought to comment on some personnel matters. First, despite the presentation of the growth and decline of populations that we heard this morning, and particularly the question of the aging of the Bureau, I don't truly understand the Secretary's chart on aging. The fact is, in important key areas involved in metrology, the average age of the technical staff at the Bureau of Standards is rising.

Mr. WALGREN. Is rising?

Dr. SLICHTER. Is rising, the average age is rising. And this is an inevitable result of past hiring constraints. The effect is that in a number of areas of measurement services, the formation of standards and the issuance of references have become really quite thin.

Now, some of this work will—as Dr. Branscomb pointed out this morning—in the fullness of time, be phased out, to be taken up elsewhere. There are bodies—organizations in the country that deal with the standards in a manner that—for example, as secondary standards—are important commercial sources of information of this character.

However, if the process of aging in these critical areas is not reversed, surely the Bureau is going to be in trouble in some important ways.

A comment was made this morning on the question of salary and competition for employment. There's probably no need to say anything further about the issue of growth in the ranks of GS-11 to GS-15. Clearly that's the area in which the competitive position of the Bureau is weakest, vis-a-vis industry. And the Board of Assessment is worried about the impact of the command of the administration to bring about reductions in this critical area of the population.

Dr. Branscomb has commented on the valuable program that the Bureau has for temporarily employing young scientists who have just finished their doctoral education. Universities have long offered such career opportunities in large numbers. Postdocs, as they're called, are a common way point in a career of young scientists.

The Bureau invokes postdoctoral positions as an important adjunct in its recruiting and screening practices, and gets great benefit from the productivity of its postdoctoral people. Therefore, any important setback in the postdoctoral program would be a very severe blow indeed.

The role of guest workers, as they are called at the Bureau, coming from industry and the professions to work collaboratively on the Bureau's premises, actually is quite an old program. There has been a program on dental research for 30 or more years, and it's a tremendously important activity. It serves to join together the research in existence among Government, universities, and industry.

As for the programs and facilities at Gaithersburg, the Board of Assessment is pleased to see the installation there of a very advanced computer—which is still, indeed, in the process of being brought it onto line. It's a very effective institution already serving a broad constituency of scientists and technologists within the Bureau and elsewhere in Government.

A very fine prospect exists for the Bureau to become a national center of excellence in scientific computing, and probably the Bureau is unique in this potential within the Government. But as it exists, however, hiring restrictions could result in an underutilized resource.

I won't say more about the topic of the cold neutron facility. That's been well covered, and the Board of Assessment is thoroughly in agreement with the view that the facility should be an important part of the function of the Bureau of Standards, and it would be very well placed there.

To conclude, Mr. Chairman, I'd like to state again my conviction, both as an individual scientist and speaking for the panel's evaluation, that the Bureau of Standards is an extraordinary national asset. It is at once a wonderful blend of the traditional and the very new, and it's service in both traditional activities and at the forefront of science represent a true bargain in modern services from the Government.

More and more the Bureau should exert leadership in technical areas. The preservation of these capabilities and the timely extension of the activities of the Bureau are exceedingly important to the nation.

Thank you again for the opportunity to present these views.

[The prepared statement of Dr. Slichter follows:]

Statement of

WILLIAM P. SLICHTER
Chairman

Board on Assessment of Programs of the
National Bureau of Standards

Mr. Chairman and Members of the Subcommittee:

I am pleased to be invited to this meeting to express some views of the present activities and the future role of the National Bureau of Standards. As an individual scientist, I have been closely aware of the activities of the Bureau for 25 years, and have repeatedly taken part with its people in technical matters.

My special role here today is that of Chairman of the Assessment Panels for the programs of the National Bureau of Standards. These Panels serve under authority of the National Research Council, which since 1959 has provided a continuing evaluation of the functions and operations of the Bureau. They consider importance and relative priority of projects, quality of staff, equipment needs, finances, and the relation of the program to the mission of the Bureau. They provide a continuing contact between the scientists and engineers of the industrial and academic communities and the Bureau staff.

The Panels consist of about 20 committees. They are made up of scientists and engineers drawn from universities, industries, national laboratories, and other professional bodies. At present there are about 200 panelists, each of whom serves in rotation and each of whom is chosen under the close supervision of the National Research Council. Over the years, about 2,500 technical experts have served on the Panels. The formal reports of the Panels are reviewed through the procedures of the National Research Council and become public documents.

You are well aware of the Bureau's role as custodian of the Nation's fundamental units of measurement and as the Nation's primary measurement laboratory. The Bureau has recognized that the faithful discharge of its duties as a standards organization depends upon having a truly basic role in the science and technology underlying the fundamental quantities that are measured. Accordingly, the Bureau maintains on-going excellence in scientific research. This excellence is vital not only to the internal needs of the institution but, even more importantly, it underlies the communication between the Bureau and the many constituencies in government, industry, and academe that it serves.

The Board on Assessment believes that the Bureau of Standards is in excellent health. The Bureau is performing its mission with dedication, objectivity, enthusiasm, and assurance. Please let me note that this good state of affairs stems in important degree from the deep understanding and sensitive support that Secretary Baldrige and Deputy Secretary Brown have shown to the Bureau. This attentiveness is a very strong encouragement to the managers and workers at the Bureau, and is an important factor in the excellent morale in the institution at all levels.

Please let me offer a comment, looking back on many years in the business of scientific research, that sustained support is essential to productivity in research. The ups and downs that are the inevitable part of the quest for knowledge are challenge enough, but they are rendered well worth the doing in the presence of continuing encouragement. The present state of confidence on the part of the Bureau's people has not always prevailed. Thirty years ago, for example, the organization underwent a severe and wrongful attack upon its objectivity. Several years ago, the Bureau experienced a major reduction in force which had a clearly damaging effect on morale.

The State of Research

Mr. Chairman, you asked me in your letter to say what I think the Bureau should be doing to continue its long tradition of excellence in state-of-the-art research and its leadership in development of standards required by U. S. industry. With regard to excellence in research, I think it is vital to remembe that the pace of research in the world continues unabated. Indeed, the vigor of research in America is this country's best answer to the challenges of foreign industry. No alternative exists to insuring that our science and technology are at the cutting edge. Since the Bureau of Standards is the custodian of all units of physical measurement on which the Nation's scientific and industrial measurements are ultimately based, it must carry out a program that matches the pace of technology everywhere.

New Ventures

The Bureau of Standards has received good but not extraordinary attention from the Administration and the Congress in recent years for its research. One very positive example of this attention is the continuing support of the Competence Program, which is extending the capabilities of the Bureau into valuable new areas. The current activities in new competences include biotechnology, an area in which the scientific developments are everywhere occuring with almost explosive speed. The Congress has responded with vision in understanding the opportunities that these new competences convey to the Nation, and has regularly supported these initiatives in the appropriation process.

It is important for the Bureau to be given strong incentive to think about the future. The statutory Visiting Committee and especially the Assessment Panels can be useful to the Bureau in judging the priorities, but the basic challenge belongs to the Bureau itself.

Research in Measurement Science

Some may ask if the Bureau is not just about at the satisfactory end of its need to refine the precision of measurement. The answer in part is that people in science, commerce, industry, and international affairs intrinsically operate under a basic need for greater accuracy and greater precision in measured quantities. When a better standard of measurement is found, some people inevitably make use of it. For example, to the scientist an improvement in the accuracy of measurement of even such an ancient quantity as the volt may be critical in the planning or resolution of basic experiments. In international affairs, an improvement in the portability of the ampere may have important bearing on commerce between nations.

At the Bureau of Standards, the people responsible for this work are at the leading edge of science and technology; what they need has impact on much of industry and universities. Unforeseen as some of these results may be, their occurrence is ample reason for having a continuing exploration of these frontiers. While some of this work stems naturally from academia and from large industrial laboratories, the central role clearly is part of the mission of the NBS.

Some of the notable work that has brought recognition to the Bureau is in the domain of pure research. For in addition to the needs of commerce and industry to depend upon ever more reliable standards, there is compelling need in science at the Bureau for ever more accurate measurements to refine our understanding of Nature. To achieve these goals, the staff must really be on the front line with their own achievements, in orde to converse with the whole scientific community.

The Future of Measurement and Data

Still central to NBS for the future will be the provision of standards, reference materials, data compilations, and measurement assurance programs. These ongoing activities are the very essence of the Bureau's mission. They are always under budgetary pressure. Some of them are unglamorous and seemingly routine. Nevertheless, over the years these functions have held their own, and have moved forward into new areas. The NBS management has done a good job of ordering priorities under the constraints of available resources. The Panels of Assessment regard these functions as truly basic to the Bureau's job: work of this sort will always have to be done.

In contemplating the Bureau's future, I should like to comment on some personnel matters. First, the average age of the technical staff at NBS is rising, and has been for several years. This effect is the inevitable result of the hiring constraints. A net effect, however, is that a number of areas in measurement services, notably those related to the affirmation of standards and the issuance of references, have gradually become very thin. To be good at this critical work demands a lot of experience on top of formal training. The management of the Bureau responds, as is only sensible, by discontinuing certain lines of effort when required talent is lost through attrition. If this movement is not reversed by relief in limitations on hiring, part of the role of basic standardization will be voided in this country, and secondary standards without accountability will be the only remaining resource to commerce and industry. Likewise, the position of the United States in international standards will be eroded, with inevitable damage to the Nation's position in foreign trade and foreign influence.

Salary and Employment Matters

The President's broad program to reduce the national deficit has found that growth in the ranks of middle management employees, Grades GS-11 to GS-15, is too large. The proposed reduction in the work force in this area is seen by many as a way to decrease in expense and a gain in efficiency of operatio The Board of Assessment is worried, however, about the special impact of this reduction on NBS.

The grades GS-11 through GS-15 correspond to the salary levels of many non-managerial scientists and technologists in the Bureau. These levels correspond to what industry routinely pays to comparable people in similar jobs. In fact, the salari for such jobs in industry tend to be somewhat higher than at NBS, but the Bureau is able to offset the differences in many cases by the appeal of its environment.

The Board on Assessment believes the President's program was not intended to have such an impact on the employment of non-managerial employees whose services occur in critical areas

We see this policy as adverse at NBS for the retention of valued employees for the recruiting of new scientists and engineers.

Temporary Employees and Guest Workers

NBS has an active and highly valuable program for temporarily employing young scientists who have just finished their doctoral education. Universities have long offered such career opportunities in large numbers. These postdoctoral posts are very well recognized as being of great mutual value to both employer and employee. Postdoctoral programs are not common outside of universities. My own organization is one of only a few to have such a program. The Bureau gets great benefit from the productivity of its postdoctoral people. It also uses its postdoctoral program as an element in its search and screening process in the hiring of regular technical employees. The postdoctoral activity is highly cost effective and ought to be enlarged.

In a different arena, the Bureau has long had a substantial program of guest workers. These people come from industry and the professions to work collaboratively on the Bureau's premises. Their support is from their own institutions, but their accomodations in research come from the Bureau. This activity is a remarkable undertaking that serves to join together research among government, universities, and industry.

Programs and Facilities

The Board on Assessment is glad to see the installation at Gaithersburg of a very advanced computer, with the support of Congress. This machine is already serving a broad constituency of scientists and technologists within the Bureau and elsewhere in government, notably the National Oceanic and Atmospheric Administration/Environmental Research Laboratories. This facility gives every assurance of bringing together the skills of many separate groups. A fine prospect exists for the Bureau to become a national center of excellence in scientific computing. NBS is unique in this potential. A hazard exists, however, that hiring restrictions could result in an underutilized resource.

The Bureau continues to move forward in major areas that have broad impact in the technical community. Prominent among these is the Cold Neutron Facility, with which you are familiar. This major expansion of the nuclear reactor at Gaithersburg will provide the Nation with its only capability in the fields of physics and materials science that depend on the advanced technology of cold neutrons. Institutions abroad, most notably in France but also in other nations such as Great Britain, Germany, and Japan, already possess or soon will have the capability for this branch of research. My advocacy is based on the conviction that our scientists encounter a severe loss in efficiency when they must go abroad for their work, and that the Nation would be best served by having this field of science at home.

Concluding Remarks

In conclusion, Mr. Chairman, I wish to state again my conviction that the National Bureau of Standards is an extraordinary national asset. It is a wonderful blend of the traditional and the very new. Its service and dedication to the classical fields of metrology, standards, and data are essential to the functions of science, commerce, and industry. But these traditional activities, important though they are, do not suffice for the Bureau's mission in the remainder of the century. First, the Bureau must expand vigorously upon its initiatives in research at the forefront of physical science. The boundaries of the sciences pertinent to the Bureau are far ranging and should be continually probed. Second, the Bureau occupies a central position of growing importance within the range of skills of government laboratories. More and more, the Bureau should exert leadership in these technical areas.

I profoundly admire the people of the Bureau of Standards for their complete dedication to service, their integrity in science and technology, their belief in their work, and the supreme quality of the accomplishments. The preservation of its capabilities and the timely extension of its activities are exceedingly important to the Nation.

I fully recognize that the Subcommittee on Science, Research, and Technology knows about this importance. I again offer my thanks for the opportunity to testify.

Mr. Walgren. Thank you, Dr. Slichter.

You mentioned something that I didn't quite catch, and I wanted to be sure that I heard correctly. Just after you were talking about the rising ages, you indicated that the Board of Assessment was concerned about a certain factor, and I didn't get that. From your written testimony, I see the Board's concern with the GS-11, GS-15 problem. Was that what you were referring to at that point, or was there another——

Dr. Slichter. You're correct, we are concerned with that. But the problem that I spoke to, that you're asking about, has to do with competences in certain areas of metrology and standards, and the like, that depend upon the accumulated skill of an individual who comes to the Bureau and has been there for a long time, and has learned the skills and the basic science and is applying it and his replacement has not yet been provided.

As these people gradually retire, the acquired knowledge and the broad base of experience to do the job is disappearing.

Metrological qualifications are not taught in a very concentrated way by universities. You can't go to class and learn—let me say that differently. People don't take courses in metrology at universities. There are courses that lead to degrees, and people come to the Bureau of Standards and are engaged to do work in fields of great complexity and great difficulty, and they learn on the job. And those people, many of them—as we visit—seem to be growing older and are not to be replaced by younger people.

Mr. Walgren. And they would not be reached by the influx of young people at that point?

Dr. Slichter. Well, it takes many years. And I'm probably not as well qualified to speak to the internal operation as Dr. Branscomb is, but it's very clear that this is a skill peculiar to the Bureau of Standards. It's not something that derives from academic experience.

Mr. Walgren. OK. Let me ask about this dichotomy between the creation of standards and the conduct of or the carrying out of basic research—the more limited view and the more expansive view of the role that NBS must play—do you feel that the charter of the organization itself should be updated and changed to recognize a more creative role for NBS than might be under the original language?

Can I get general responses to that, Dr. Branscomb, and all the other panelists?

Dr. Branscomb. I think what's needed is a consensus, a more general consensus on the Bureau's mission to only interpretation of the statutory provision—and I doubt that changing the words in the act would cause such a consensus to exist. On the other hand, a study of how that might be done is a way to test the consensus.

At the Bureau of Standards, in my many years there, we often went through cycles perhaps once every 8 or 10 years when there was serious discussion in the administration or in the Congress about changing the name of the National Bureau of Standards. I personally have been very sympathetic to the notion of changing its name, if we could simply think of a name to change it to. We've all been frustrated in solving that problem.

The image of the Bureau of Standards is that of a legislative body or an administrative law body that somehow sets rules. And that head picture that people have from those words is so far from the reality that it really does cause a lot of trouble. The Bureau of Standards does not set industrial standards. The Bureau of Standards does research on test methods, it does research in the science of measurement, it does research on the properties of materials, and importantly it does research of such a character as to boom out these qualities.

In a paper, which I've asked in my formal testimony be also printed in the record, a speech I gave at Argonne Laboratory on the National Laboratories in the Nineties, I tell in there the story of my view as a young scientist at NBS. That the Bureau of Standards doesn't need to have a tightly constraining mission aimed at standards and measurement science, for it is an institution that glories in quantitative work. And if you get good people there and turn them loose, they will invent standards, they will invent measurement methods, they'll be highly motivated.

The short answer to your question is I believe the act provides all the scope necessary for the mission that the Bureau in fact carries out. But there is a severe lack of understanding in what that mission is. The Bureau's programs are much more compatible with those of the universities supported by the NSF, than Mr. Ritter apparently believes. And at the same time, the NSF is much more devoted to strengthening the roots of American science and technology than it's given credit for.

And I feel that in both cases, the changing of the language may help to codify a new consensus if one can be reached. But what we really have to do is be sure that everybody on both sides of all the aisles that are involved in this debate truly understands what the purpose of the laboratory is. And I think the Commerce Department's own narrow conception of its own view inhibits them from that understanding.

Mr. WALGREN. Other comments?

Dr. ANCKER-JOHNSON. I think the Organic Act is quite general enough. The most important thing is that those who understand the Bureau from inside be given the leadership opportunity to continue the tradition of doing basic research which has led to the strengthening of science and technology in our country. That's the issue, not the language.

Dr. SLICHTER. My feeling is similar to those of my friends. I think the Organic Act is, as some have said, intrinsically a permissive device, and I think that's just right. That although good reason has existed for the roughly 20 or so special charges made to the Bureau of Standards in the past decade or two, for good sufficient reason, nonetheless, to think that one can have the wisdom at a certain point in time to define what the Bureau should be explicitly and precisely, and then to go away and not come back repeatedly and revisit that and update it, update it, update it, is a very dangerous thing intrinsically and could harbor considerable harm.

Speaking as a customer of the Bureau, and not in my role as a panel chairman, I hope nobody changes the name of the National Bureau of Standards. I think it's a noble name.

Mr. WALGREN. In the National Science Foundation's charter, I know at least one of the most operative words in there is the direction to either enhance or increase potential. Now, that's a very powerful and far-reaching word, potential, and perhaps it has given the ability to range over some areas that NBS wouldn't otherwise have gotten involved in. I just wonder whether the charter might be limiting in its own nature.

Well, let me ask one other general question. That is, how confident are we of the health of the Bureau? I understand that good things have been said in terms of our assessing its present capabilities. But it's often true that good things are often said when the reality is that we ought to be more worried than we really are, or than those good words would lead us.

I have no direct knowledge. I've only heard it from people who go back a long time with the Bureau. They worry about its quality and the degree of respect that it now commands compared to the degree of desirability, for example, of a young scientist going to it as a first experience. Does it remain as attractive to the young scientists today as it used to be?

Dr. SLICHTER. It's hard to say. I live in a big laboratory, and people in my home worry about the future. It's in the nature of productive and creative people to wonder whether they're doing as well as they could or should. Intrinsically I think that's a very healthy attitude. To be the opposite strikes me as being considerably more worrisome. To be cocky and over confident or extremely confident and not to be self-critical I think is a portent of much greater harm than to sort of suffer a little.

As I remarked a few minutes ago, there have been times when morale at the Bureau of Standards was plain low. And all of us have been in institutions when during some point in time morale was low, and you know when the morale is low. I don't think morale is low now. I think morale is good and it's robust. That doesn't mean things couldn't be better and that people aren't planning, indeed scheming, to make things better.

And continuity of funding, increases of funding are important adjuncts to making people feel better. But when people know they're being well led and being fairly treated, and are being allowed to exercise freedom of thought, I think the place is intrinsically in good health.

Mr. WALGREN. Dr. Branscomb?

Dr. BRANSCOMB. I think if one makes critical statements about the intellectual quality in the laboratory today compared to some previous period, you always run the risk of doing a very unfair disservice to those who are still at the laboratory and who are doing tremendously good work. And yet, I can't help but feel that the Bureau's intellectual vitality could be substantially improved by several directions, one of which is to be sure that the Bureau is in a position to retain its most outstanding scientists.

I have some anecdotal information from scientists in different parts of the Bureau of Standards that they are being increasingly bombarded with job offers elsewhere, often from universities paying exceptionally high compensation.

We've gone through a long cycle. When I went to the Bureau of Standards, universities paid less well than did Government laboratories. Then there was a long period of time when the universities paid much better, then the Government caught up, and the universities sagged behind in the 1970's, and for a period of time the Government paid better than the universities. Now I think that's rapidly reversing again, at least for the very top people. So, one should worry a lot about the retention of very top people.

Second, there are some areas in which the Bureau cannot attract the very top people. And you can't say the ones that are there aren't good, it's the ones that are not there that are significant. And it's been mentioned before that that's conspicuously true in computer science where compensation levels are differentially higher than they are in other fields to meet marketplace realities. It's a little like paying doctors rather than paying physicists when you hire a computer expert.

The Bureau of Standards clearly has a problem in that area. And I think the Government's personnel organization needs to make special provision in that area to be competitive.

Finally, I think there's an aura around the laboratory, and the word gets around. If the general sense in the community is that its mission is understood and supported by the principal leaders and Government, upon whom it depends, that it's not a matter of controversy, whether this laboratory should be encouraged or discouraged, then people feel better about going there. Those are subtle influences.

The extent to which the laboratory's management takes a leadership role in Government, in the debates about science policy and roles and missions, also I think gives you a sense of dynamism that helps attract people.

So, I'm certainly not prepared to question any of the favorable report cards given by these fine panels of people who visit the Bureau quite comprehensively. And I think their report card has to be believed. Nevertheless, I do believe that there's reason for concern.

Mr. WALGREN. Let me give an opportunity to our two staff people to raise some points with you. They sit here, by and large, trying to deal with the frustration of trying to get questions asked through other people. We have a little time, so let me ask Maryanne Bach if she'd like to raise any point.

Ms. BACH. Thank you, Mr. Chairman. Actually, I think it would be beneficial for the members who weren't able to stay if I repeated the question you posed to Deputy Secretary Brown about the value of the competence fund.

And I think from your perspective, as being senior scientists involved in management—whether it's from a Federal R&D arena or in your own labs—I think you have a very solid appreciation of what flexibility a director needs. So, I think it would be valuable for you to comment on a source of funding that is somewhat discretionary, however given your understanding of that competence fund. If you could comment please.

Dr. BRANSCOMB. Well, I think it's a 100 percent, superidea, and it's exactly that kind of thing that sends a message out to future recruits that this is the kind of place where somebody cares about competence enough to name the fund that. My only concern would be to ensure that that fund in fact is used to stimulate competence and doesn't become simply a pot of flexible investment money for changing the program.

It really ought to be invested, in my view, in whatever the Director believes is the most critical element in making the scientists better at the Bureau of Standards.

Dr. ANCKER-JOHNSON. But that flexibility is just absolutely essential for nuturing the kind of competence that you want to have in such a place as NBS or any good laboratory. Its absence during my time in charge of the Bureau was one of my greatest frustrations, because the inflexibility then did not allow the recognition of that work which really should be given a boost and encouraged. It certainly is a way to signal throughout that scientific community that you care about good work and you tend to reward it and encourage it. The Director's fund certainly should be maintained and continued.

Dr. SLICHTER. I couldn't agree more with my two friends, that I can't imagine running a worthy, first class, progressive operation without competence funding. In artillery terms, it's a target of opportunity sort of funding. It allows one to act swiftly and move into an area where opportunity can create new ideas and new productivity in a big hurry. It's envigorating to have around.

Mr. WALGREN. I'm hearing two things there. On the one hand, directing the money to assure competence in terms of the best personnel and the best skills involved, and on the other I'm hearing the general ability of the agency to take advantage of opportunities that might come along during the year to develop a particular insight or a particular area of interest as opposed to a level of skill.

I don't know enough about this to speak about it. Are there two functions here? I understand the President's National Laboratory Commission suggested that budgets be 10 percent directed toward one of those functions. I don't know which it was, but one of them. How do those two functions play out?

Dr. ANCKER-JOHNSON. I would certainly say there's absolutely no contradiction there because invariably the most competent people are those that recognize the particular problems in science which are at the moment most important. And those are exactly the ones from a programatic standpoint that you want to fund, and almost invariably the brightest people are led into those new discovery areas.

Mr. WALGREN. I just——

Dr. SLICHTER. For new activities don't wait for the start of a budget cycle. And to have the flexibility and the capacity to do something when you know something is truly right.

Mr. WALGREN. So you see this fund as really an ability of the management to engage in new activities that come along.

Dr. SLICHTER. I think that what Dr. Branscomb and I were saying, and that Dr. Ancker-Johnson has explained further, are part and parcel the same thing. The danger—not a real danger to the Bureau, but the danger with having extra funds around, wherever it may be, is that you use extra funds to solve untidy problems of overspending and the like. You have to maintain competence funding, as the Bureau has been doing, for the capitalization on something that will be new and important.

Dr. Branscomb. Could I just elaborate a bit. There need be no conflict in what we've said. The initiation of a new project of the Bureau's own choosing is often the best way to attract exciting young people and to build a sense of elan in the institution.

I was only warning against the possibility that given such a fund, highly visible outside the Bureau as well as inside, it would be a frustration of its purpose should the Bureau be in effect forced to use those funds to pay for some pragmatic project that it failed to get funding for, or that had a cost overrun or had some other difficulties.

But, in fact, the substantial part of the Bureau's investment—not this small competence fund, but the substantial part of its appropriation needs to be invested to be sure that the capability is there, the competence is there to respond to the needs as they come in.

I was impressed when Secretary Brown mentioned that the Bureau is now getting some $58 million from the private sector. I'm not quite sure what all that contains, but if I had to guess, I would guess that $20 million of it are the 200 guest workers from industry. And those people do make a contribution to the Bureau's research, but they're also there to learn and be helped.

The Bureau has to have a competence or it can't attract—those people won't come. They are not a substitute for Federal dollars. They are a response to the success of the Federal investment in creating competence.

So, I just wanted to make, No. 1, a plea that the whole Bureau program should be run to ensure its competence; and No. 2, it is very desirable that the Director have a small fund which is specifically in advance protected against the hard question to justify that expenditure. He should not have to justify those expenditures. If he wants to bring some people in to do some very pure research because he thinks it's important to stimulate the laboratory, he shouldn't be hassled for doing it in that fund. And in the rest of the laboratory he clearly needs to account pragmatically for what he's doing.

Mr. Walgren. I am still confused between the concept of competence as capability in a new area versus competence as ability to carry out a task in an area in which you have already been working.

Dr. Branscomb. But that confusion is perfectly all right. You're all right to be confused about that because those two things are in fact not discernable. Any laboratory manager will do both of those as part of one strategy. And my concern was only against the invasion of this fund for inappropriate purposes, that's all.

Mr. Walgren. Have we had full funding of the competence fund in the recent years?

Dr. Slichter. Yes.

Mr. Walgren. And that is 10 percent? Is that considered adequate?

Dr. Slichter. Don't trust my memory on that. I think it's less than the number of 10. But it is a discretionary fund in the hands of the Director, which he uses with great selectivity.

Mr. Walgren. Mr. Turner, would you like to raise anything?

Mr. Turner. I just have one quick question following up on that. Deputy Secretary Brown talked about the competence fund and other funds at the discretion of the Director. Are there such funds that are similar to the competence fund, or was that sort of a euphemism?

Dr. SLICHTER. Gee, I don't think so.

Dr. BRANSCOMB. Well, I would surely hope that both this committee and the secretarial offices in the Commerce Department accord the Director the full flexibility to pursue the objectives to which he's committed in the Authorization and Appropriations Act, with all the flexibility that's appropriate for that pursuit.

And I remember that when I was Director, we had 1,000 scientists on the staff—I think the number is still about the same—and we had 1,500 projects. And that struck me as no way to run a laboratory. That's where we lost our flexibility. And it was largely self inflicted.

Mr. TURNER. Switching to another subject, Congressman Walgren earlier alluded to the fact that money from different sources, other than the STRS appropriation sometimes has strings attached to it. Is there an optimum mix of funds coming from other sources, from industry or from other agencies?

Dr. BRANSCOMB. When I was the Director, about 40 percent of our total appropriation, total expenditures, came from other agency reimbursements. I felt at the time that that was dangerously high, and I established for the laboratory a goal of 33 percent, and we worked toward that during the years that I was Director. It never quite got that low.

I'm astonished to discover it's now more like 50 percent. And I think that's dangerously high. The other agencies need to call upon an existing capability. They cannot be expected to fund the creation of the capability. And I think once the service to other agencies reaches half the total, then it's hard to imagine that the Bureau is really a master of its own fate. So, I'd be concerned about that.

Now, I know that Mr. Brown, if he were here, would say well you didn't do the arithmetic right. We need to add the $58 million from the private sector to the total, and then the percentage is smaller. I don't know what's in the $58 million, but you need to understand that. At least I would suspect that some of it is for activity that was always there which we didn't count as part of the budget because it did not go through the Bureau's expenditure process.

And if indeed the Bureau has $58 million of reimbursed work that actually goes through its accounting process, then I'd begin to worry about that being too big, too.

Mr. TURNER. In your opinion, we have a chart that shows that the number of employees has dropped from about 3,600 to 2,900 over the last 20 years. And do you think the physical plant of the Bureau is underutilized at this point, or have those been made up by guest workers?

Dr. SLICHTER. Well, I don't think the physical plant of the Bureau is underutilized. They are not uncomfortable. I don't see any gross underutilization. It is a fact that doing technical work nowadays requires substantially more space than it did 20 years ago. I certainly see that in my institution.

Machines get bigger, and dedicated computers in laboratories exist now where they didn't exist 20 years ago. The Bureau is not lush in its occupancy of space; it's quite the opposite. It has about the amount of space that this operation requires.

Mr. **Turner**. And one followup question to that is to Dr. Branscomb. You were talking about spinoffs, and the spinoff reasons seem to be budgetary reasons. It would seem to me that space might be another reason. And I wonder, are there ground rules to know when we should look to spin certain activities off and other activities that really should be looked at at this time?

Dr. **Branscomb**. I'll make a suggestion. Ask the Congressional Research Service to do a quick study for you of the history of spinoff institutions from the Bureau of Standards, and ask them that question.

I think you'll find that in those cases where the spinoff worked—that is, the new institution took off and was successful—it was a circumstance in which it was clear that the Bureau's own desire to retain its character as a laboratory rather than as a broad purposed agency was exerting an undesirable constraint on the Federal Government's ability to cause something in the country to happen. And the spinoff was for the purpose of allowing a new institution with a more specialized scope, but one that went beyond research, to take off and be successful.

So, the Bureau was the original home for the NACA, which Hugh Dryden ran. And when time came to create a NASA, that was the test bed for it. But clearly the NBS couldn't internalize a NASA.

The Bureau of Standards was the place where the Manhattan project started. Clearly you couldn't have carried out a Manhattan project on the grounds of Van Ness Street and Connecticut Avenue. And so, in those cases there was a quite deliberate and careful construction at high levels of the Government of a new institution. Often it was another Government agency, and the Government was growing then, but today it could just as well be a private agency, if that in fact can be made to happen.

But it ought to happen because the new institution is a better place for it to be, not because the Government has gotten tired of doing something that's necessary that nobody else wants to do.

Mr. **Turner**. Thank you.

Mr. **Walgren**. Well, on behalf of the subcommittee, we certainly appreciate your testimonies and have found it most interesting. We would like to follow-up with you, as is our want from time to time. And we appreciate your responding when we do, as you are such good resources.

And knowing that NBS was the original start of NASA and the Manhattan project, that by itself probably will or should be able to generate substantially greater support for NBS on the floor of the House of Representatives than almost any other thing we've come across this morning.

So, thank you very much for all of your patience and for the contributions you've made.

[Whereupon, the hearing was concluded at 1:55 p.m.]

THE FUTURE ROLE AND MISSION OF THE NATIONAL BUREAU OF STANDARDS

WEDNESDAY, OCTOBER 2, 1985

House of Representatives,
Committee on Science and Technology,
Subcommittee on Science, Research and Technology,
Washington, DC.

The subcommittee met, pursuant to call, at 2:08 p.m., in room 2318, Rayburn House Office Building, Hon. Doug Walgren (chairman of the subcommittee) presiding.

Mr. Walgren. Well, let me welcome you to the second day of hearings on "The Future Role and Mission of the National Bureau of Standards." For those who were here yesterday, we had, as you know, witnesses from the White House Office of Science and Technology Policy, the Department of Commerce, and a number of senior scientists from industry who have had a major involvement with the National Bureau of Standards at various times in their careers or presently. I think it is fair to say that their views of the importance of the Bureau and the potential of the Bureau are very positive and very clear about the contribution that the Bureau can make to our economy, both presently and in the future.

We have scheduled these hearings to try to develop a longer range record about the future of the Bureau of Standards that may serve as helpful background when this committee deals with the annual authorization process which, by definition, takes a shorter frame of view. I think it is often underestimated how difficult it is for people who are not engineers, or who are not scientists, to appreciate the importance of the kinds of contributions that the Bureau of Standards makes to our economy and to our society.

Certainly the realization that the Bureau of Standards is really, in essence, a research organization is not one that comes immediately to the mind of most Members of Congress, and it is important that we try to understand that in every formal way that we can, so that NBS receives the proper support in those areas where they need it.

It is certainly fair to say that this committee has been supportive of the Bureau in our involvement with them over the last number of years. We would like to see the administration be as supportive of the Bureau as well, and hope that will develop as each budget year comes along. We certainly hope that the Bureau will be able to plan, with support from within the administration, for the same kinds of increased effort that we see in other science agencies, other research agencies in our Government. We hope in the process of this hearing to develop the kinds of concrete views that any future actor in this play will have to take account of. I hope that we can contribute in that way.

Today, we are going to hear from the leadership at the Bureau of Standards; from the heads of several of the universities that have a great deal of involvement with the Bureau of Standards, and from several other industry leaders who have both worked with the Bureau over the years and who have a view about the future of our economy and how we are going to have to organize ourselves if we are to make the most of it. We look forward to these witnesses and want to welcome you to the committee and thank you at the outset for your contributions to this record.

[The prepared opening statement of Mr. Walgren follows:]

OPENING STATEMENT OF CONGRESSMAN DOUG WALGREN

Today we conclude our hearings on the Future Role and Mission of the National Bureau of Standards. Yesterday we heard from the White House Office of Science and Technology Policy, the Department of Commerce, and a Distinguished panel of senior scientists from industry who had major roles in running the National Bureau of Standards Earlier in their careers. We were given important insights into the rich history and promising future of the Bureau. We were pleased, despite the Bureau's budget problems in recent years, with the general feeling that NBS still is state-of-the-art in many areas and has not slipped to the point where return to its glory days is out of the question.

We have scheduled these hearings to probe the long-range future of the NBS at a greater depth than we are able under the pressures of the annual authorization. It is our goal to aquire the knowledge which will help us respond intelligently to future funding requests for NBS. We are eager to learn more about the future directions the Bureau expects to take this century, what industry needs from the Bureau, and the prospects for increased cooperation between the Bureau and the universities. We hope to be supportive in these efforts. We want to make it easier for NBS to help American industry to meet foreign competition head-on but we also know NBS must keep up its excellent standards support to industry across the board, including the computer and construction industries.

We are not so naive as to believe that NBS can develop tomorrow's standards with yesteryear's budget. Budget freezes come and go. We trust that someone in the Department of Commerce is looking ahead, as is being done in NSF, and figuring out just what it will take financially to unlock the Bureau's great potential. This Committee showed last year that it is ready to stand up for the NBS, and we are ready to try again to give the Bureau the resources it needs. However, we and our Senate counterparts can't fight the whole battle ourselves. We need help and leadership from the other side of town.

Today we will hear from the leadership of the Bureau of Standards, from the heads of universities located near the NBS, and from two additional industry leaders with long working relationships with the Bureau. We, therefore, are certain to increase our knowledge of this vital laboratory even further today. We are pleased once again to have such distinguished witnesses and look forward to your insights.

Mr. WALGREN. Are there any other members who would like to make any opening comments?

[The prepared opening statement of Mr. Boehlert follows:]

OPENING STATEMENT OF HON. SHERWOOD BOEHLERT

I would like to endorse he comments of the Chairman. This subcommittee is of the feeling that the National Bureau of Standards is the focal point for providing the U.S. with the tools it requires in order to regain its position as the global leader in advanced and manufacturing technologies. We have wrestled in the recent past with budgetary contraints which seemingly require trade-offs of intrinsic missions for new missions. We must develop a means for promoting frontier technologies at the Bureau without sacrificing the important basics.

Our goal is to make the public, the Congress and the Administration aware of the vital role which the Bureau assumes and must continue to assume if we intend to win the global technological/economic race.

I look forward to the thoughts of our distinguished guests this afternoon.

Mr. Henry. Thank you, Mr. Chairman. As you know from our informal discussion just a minute ago, it is only 8 months ago I first met Dr. Ambler and got thrown into this. I have to say, from the contacts I have had with businesses in my district in the interim—as they have been advised as to what I'm doing and I've been informed as to what they're trying to do—I have heard great appreciation expressed to their direct involvement and/or hearsay involvement of related firms with which they deal, speaking very openly as to how you're literally kind of in recent years opening the doors of your Agency in a much more aggressive way, of, I guess you could say, assistance in kind—Is that—I'm trying—payment in kind for farmers and assistance in kind for industrial and engineering assistance. I want you to know I've heard that, and sharing of your reference materials in a much more aggressive kind of way.

Given the budget constraints, I presume from the hearing there is still a fundamental underlying need for the competitive staff positions in which you are hurting, the need for much more by way of instrumentation and support there, given the terrible cost. I just wanted to say we don't know each other well, but I've been very impressed by what I've heard from businesses who are very sensitive to, I think, an opening of your Agency in ways that are new to them.

Historically, you have always been the fundamental way by which we measure. You can't move forward in science without measuring. But in terms of welcoming them literally into your facilities, you should know that even out in the field people are aware.

Thank you.

Mr. Walgren. Thank you, Mr. Henry.

Mr. Brown, any opening thoughts?

Mr. Brown. No.

Mr. Walgren. Well, with that, let's have first then Dr. Ambler, who is the Director of the National Bureau of Standards. He is accompanied by Ray Kammer, the Deputy Director. Welcome to the committee. At the outset we should say that written comments will be reproduced in full in the record of the hearings, so that you can feel free to summarize, outline, or otherwise emphasize in whatever way you feel most effective, those points that you would like to raise with the committee and for the record that will be worked with by others over the next year or so.

We appreciate your coming, Dr. Ambler, very much, and have appreciated the spirit with which you have related to the committee during your period as the leader of the Bureau of Standards. We look forward to your discussion on this subject with us.

STATEMENT OF DR. ERNEST AMBLER, DIRECTOR, NATIONAL BUREAU OF STANDARDS; ACCOMPANIED BY RAYMOND KAMMER, DEPUTY DIRECTOR

Dr. AMBLER. Thank you very much, Mr. Chairman. I will in that case summarize my written statement.

I appreciate your opening remarks. In turn, I am very pleased again to appear before this subcommittee to consider the future role and mission of the National Bureau of Standards.

In the first part of my statement I reiterate my conviction that our Organic Act has served us well. It has given us a clear and consistent direction and a sound basis for discussion of our programs. I refer in the full statement to the stepped-up support for the U.S. economy and give several indicators of the increasing strength of our cooperation with industry, and I was very pleased, sir, to hear your remarks that you have observed that from your district, also, because we have been measuring it and it is going up.

I report that our decision to allow proprietary research is being implemented very smoothly, no problems, and everybody is satisfied and industry has benefited.

I refer to our last oversight hearings before this subcommittee, the review of the NBS Organic Act, which took place in June 1981. There was a concern expressed at that time by some of the witnesses that NBS might be straying from its traditional mission of providing measurements and standards services, that we were being drawn or pushed into putting too much research attention on sophisticated science to the detriment of traditional services such as weights and measures support to State and local governments and calibration services for industrial users.

I give details of a number of actions we have taken since that time that have greatly reduced these concerns. But as Director, I am constantly forced to realize that the National Bureau of Standards must respond to a wide spectrum of customers. These include industrial firms, individual scientists and engineers, other Federal agencies, Federal, State and local regulatory officials, particularly those involved in issues of public health and safety, and to serve this broad array of customers we must maintain an equally broad range of technical expertise and services.

So as we move to meet the measurement demands of emerging high technology, as we must, we simply cannot abandon already-established measurement services to industry. Indeed, as a rule, existing measurement services must be continually upgraded because demands for accuracy become more stringent. They just don't go away.

I would like to illustrate this with our experience in the electrical measurements area. I'm just going to pick that area as an illustration.

NBS has, since its founding, provided DC voltage measurement services to industry and others. Over the last 80 years, the level of accuracy needed by industry for routine operations has increased a thousandfold. We have responded to this changing requirement and NBS now maintains the voltage standard using a scientific discovery in superconductivity involving the Josephson effect, as opposed to the traditional chemical standard cells. Soon we expect to provide a further improvement as a result of intensive research to overcome difficulties encountered in connecting some 1,500 superconducting Josephson junctions in series.

At the same time, other types of electrical measurements have to be developed, their ranges extended, and their levels of accuracy improved. Here we are talking about quantities such as current, resistance, capacitance, inductance, power, phase angle, power factor, conductivity and so on. There's a lot of different things that have to be measured. These quantities often must be measured in magnitude over ranges of a billion or more—I mentioned the volt; we have to work with the utility companies who have transmission lines that operate close to a million volts as an example—and not only for direct current but for alternating currents up to very high frequencies.

The users of these services range from manufacturers of high precision digital voltmeters to the users of watt-hour meters. All homeowners are very conscious of their utility bills. They're all conscious of that little thing on the outside of their house with a disc that goes around. These bills are based on measurements traceable to NBS, as they have been for the last 85 years. The error allowed has been less than 1 percent. But during the energy crisis in the early 1970's, we began to see demands for higher accuracy and a whole new series of electronic meters were developed. Especially demanding were the sellers and buyers of large quantities of power, such as aluminum and steel processing plants and the utility companies themselves. Their accuracy requirements are now 100 times higher than before the days of the oil embargo. Today, $125 billion of electrical power is bought and sold in this country every year, and all transactions are traceable to the Bureau of Standards. When you think that an error of 1 percent in measurement there translates to $1.25 billion, you get some idea of the economic leverage with just that one thing, the watt-hour measurements, out of one of a whole host of electrical measurements.

And then along comes modern instrumentation with high-speed digital techniques, analog-to-digital converters; the heart of every modern instrument is an A to D converter or a D to A converter. We responded by providing a calibration service for those.

We developed and continue to upgrade a range of measurement services for electromagnetic quantities needed for radar, communications equipment, microwave radiation, and satellite communications; here I am speaking about quantities such as power, attenuation, noise, standing wave ratio, antenna gain, electrical field strengths, pulse shapes, pulse forms and so on. And as an example of the effectiveness of work in that area, we have just helped the Navy save an estimated $6 million in building and testing costs for the Aegis radar antennas by using a revolutionary new measurement method developed at NBS.

One of the things that most people don't realize is that in each of these electrical areas that I'm describing you have to have a whole different set of technology; you have to have a whole net set of skills. It's not a question of just making it a little bigger or a little smaller; you've got to do it completely differently.

To illustrate the complexity of this antenna calibration, with your permission, Mr. Chairman, I have a videotape that lasts just 3 or 4 minutes that I would like to show for you, that I think will give you some idea of what I'm speaking about.

[Videotape presentation follows:]

Mr. RICHARD RIGGS. Boulder, CO, the laboratories of the National Bureau of Standards, and the scene over the past three decades of precise, detailed experiments, measuring the specific performance characteristics of antennas. Those devices that are literally the focal point of our nation's huge and vital communications and defense networks.

There were significant problems with antennas at first, problems of how to shape them and how to point them, to make sure the signal was strong and interference was minimal. They came in practically every shape and size, some like dishes, others like corkscrews, and still others that looked like pingpong paddles.

When it came time to find out if the radio and microwaves they were sending were not being misdirected, engineers would set up their measuring equipment at a distance, sometimes miles away. They were testing antennas out in the real world. It was real, but not terribly accurate. The engineers could never be sure they were measuring a wave that wasn't being affected by the ground or other kinds of interference.

I am Richard Riggs for the National Bureau of Standards. Until recently, scientists had to work outdoors when they were testing antennas. They were handicapped by the distances, by the wind, and, of course, the rest of the weather, snow and rain. The new techniques developed here in Boulder allowed them literally to move indoors.

Dr. ALLEN NEWELL. The theory that was developed said that you could come up very close to the antenna and sort of do a map, measure the map in what is called the near field, and then mathematically calculate what the far field would be.

Mr. RICHARD RIGGS. It sounds very simple. You can explain it in a paragraph or two. Was it?

Dr. ALLEN NEWELL. Well, no, it's not very simple. It involves a lot of mathematics and it involves a lot of complicated instrumentation. It involves a lot of computer programming, and you have to be very precise and very careful how all of these things go together.

Mr. RICHARD RIGGS. Physicist Allen Newell directs the work in this near field antenna laboratory. The walls and floors are covered with a spike-shaped foam material which absorbs microwave energy. It makes you feel like you've stepped into the future. The antenna being measured this day was out of an Air Force radar plane.

Data coming from this program has had its payoff in the space program, but also in industry. Communication satellites can focus their signals on land masses now where receivers are located with a great deal of accuracy. There is no wasted signal hitting the oceans. Large aerospace and defense companies have now built their own near field labs to test very complex antennas like the phased array antenna. The near field technique has proved more accurate and less costly when compared to the older, far field technique.

What really excites you about some of the stuff you have found out?

Dr. ALLEN NEWELL. Well, I think the fact that it has been so widely used and has solved a lot of really difficult problems, and the fact that, in a sense, it was developed during a period of time when these problems didn't yet exist.

Mr. RICHARD RIGGS. The antenna measurement research that has been performed at the National Bureau of Standards enjoys a strong reputation. Industry representatives have said that whenever near field antenna questions come up now, they check with NBS first.

[End videotape presentation.]

Dr. AMBLER. Thank you for allowing me to show that piece of videotape, Mr. Chairman. I must say that you probably recognize the first antenna on the setup there at Boulder. It is no secret that we're doing that.

But one of the things that I found when I was talking to Dr. Newell—you saw him in the film—and jogs my memory, I think it may be worth relating to you because it really tells a lot about the Bureau of Standards and the way we have to do our work.

The origin of this antenna work goes back 25 years, and it was an entirely different project. It was a project designed to measure the speed of light. The primary objective of that project didn't work out too well, frankly. But the whole idea of near field antenna measurements was born during that project. The development of the mathematical methods required to translate that idea to practicality took several years of effort by one of our very, very best mathematicians, a mathematician of world reknown in the theory of electromagnetic waves. And then came the engineering and the extensive computer programming that Dr. Newell described.

Well, it all worked, but the job really wasn't over by a long shot—for several reasons. Persuading industry to accept the use of this new method took an extensive effort, and that episode of technology transfer is a whole story in itself that I don't have time to go into today. But it's an example of what it really takes when you've got something, to really get it out there.

I think the significance of this personal note will be appreciated by most directors of laboratories, Government and industry alike. You have to be ready for what's unplanned and unexpected but important, and you need time to work out and test your basic ideas. Most people I think do recognize you've got to do the engineering right and you've got to do the deployment, but often you have to do it when others don't think much of the idea, even though you yourself are convinced that it's a winner. Then you have to sell the product. The story of near field antenna calibrations makes, in my view, a wonderful case study of the important features that it takes to be a world class measurement laboratory.

Well, to go on, I was describing just what goes on in the field of electrical measurements. Today high-speed communications are being carried along optical fibers as lightwave communications are being installed. In anticipation of these advances and the new services, NBS will have to provide, we have begun research under the competence program to develop basic capabilities in lightwave communications.

And yet, for all this, just as I mentioned the misgivings on the Organic Act in 1981, there were some people who expressed discontent even today, that some of our clients are unsatisfied. Recently an industry/IEEE committee on microwave standards identified additional levels of accuracy in certain measurements that were required to enhance U.S. competitiveness in foreign markets. Microwave measurements is an area that we had well under control a number of years ago, but demands for accuracy have suddenly appeared and we cannot meet them at the present time. We are moving to respond to that and a portion of the process and quality control initiative in our 1986 appropriations, which you reviewed for the subcommittee, will allow us to address that problem further.

But in illustrating the breadth of the technical areas we must cover, I have been speaking only of electrical measurements. And yet, in this area alone, 20 of the 99 industrial sectors which represent more than 10 percent of the GNP use these measurements in a significant way. But we do measurements of all kinds, and measurements of all kinds are pervasive throughout industry. High technology, high growth rate industries, spend as much as 20 percent of their value-added on measurement related activities. Together we spend about $25 billion a year on medical diagnostic measurements. Industry as a whole is spending more than $163 billion annually on physical, chemical, and engineering measurements. Many types of measurements are made, each spanning many orders of magnitude, using numerous methods, types of measurements, and technologies and techniques. All these measurements have to be uniform and accurate throughout the economy; all have to be referred to the national standards maintained and coordinated internationally by the National Bureau of Standards. That is a great responsibility, Mr. Chairman, and one which the Director of the National Bureau of Standards must always have right before him and take very seriously, and believe me, I do.

But, it really is hard to make others understand this task. We have done well in getting publicity for aspects of our work such as automation, computer security, polystyrene beads made in space. But securing an equal appreciation for a great deal of our work which is interrelated, evolving, comprehensive in its application, and takes years of painstaking effort by specially trained and dedicated individuals—that's a hard row to hoe.

That is the end of the illustration of the breadth of coverage that I go into in my written testimony, illustrating it by means of electrical measurements. And then I go on in the last section.

To respond to the question on what NBS is doing now to enable it over the next 15 years to continue its state-of-the-art research and standards leadership, a leadership that is needed to help U.S. industry be competitive at home and abroad. I will again try to summarize what I say there. They are identified in our long-range plan. I believe that was introduced yesterday. I signed off on that I think yesterday and you will be getting a copy as soon as we get it back from the printer, I assure you. We feel pleased with the ones we have done in the past. I think we have learned a lot about planning and we can do a pretty good job. But this is the way we see the next 15 years.

Improved process and quality control. You have already heard that. That will continue. This helps industry increase productivity and enhance its ability to embody new technology in commercial products and processes. A common theme is automation and the move is from postproduction inspection to in-process sensing and control.

Advanced materials will allow the design of entirely new products as well as improved performance of existing ones. NBS' top priority at present is to develop a national cold neutron research facility, which would be a world class research tool for advanced work in materials science by NBS, industry, and academia, a truly national facility. Composite materials will be developed in greater variety for a wide range of applications and the National Bureau of Standards is beginning to address that subject. Ceramics processing research is already underway at the National Bureau of Standards, and I think you heard the beginnings of that at the last authorization hearings. In the longer term, an improved understanding of the fundamental structure-function relationships will allow a greater number of tailor-made materials to be developed.

Biotechnology advances will lead to new products and processes. Refocused NBS research is developing needed data and improved understanding of the relevant biochemical processes. Effective bioprocessing measurements are needed to support the switch to the manufacture of chemicals, feedstocks, and materials by biochemical means.

Evaluated engineering data have become even more important for industries undergoing rapid technological change, particularly as engineering data bases become more integrated into computer-aided design and computer-aided manufacturing systems. We held a workshop in the Bureau of Standards about a year ago on that. If I'm not mistaken, you spoke at that, or a member of your committee—yes, Mr. Chairman, you spoke at that. The report of that workshop has received a great deal of attention and we are working now with industrial and professional groups in identifying and developing ways we can go about providing better engineering data bases. We have had discussions with the National Science Foundation on this subject and got sorted out on who is responsible for what on that.

Implementation of interface standards will help speed the interconnection of equipment into information networks. Integrated manufacturing systems, electronic mail, and remote computer data bases characterize the future industrial and business world, all of those—the computer is everywhere, of course—but all of those sooner or later are going to be interconnected in some way, and all will depend directly on the ability to exchange data among different hardware and software systems. The open systems interconnection approach of the International Standards Organization, in which we are deeply involved, is designed to accomplish this, but more testing and development will be needed before it can be fully implemented.

Optical communications will provide significant increases in speed, capacity, and reliability of communications and information processing over the next 15 years. This is creating a market with massive foreign competition from both Japan and Europe for optical fiber cables. During the next decade, integrated optoelectronics that process an all-optical signal will appear. Further down the road may be high-capacity computers that operate at lightwave frequencies. For such lightwave technology to become commercial, a whole host of measurement, technical, and standards barriers must be overcome.

Supercomputers, based on a very large number of parallel processors, will allow advances in several research and industrial areas through much higher computing performance. We have already advanced considerably in areas ranging from aircraft design to basic chemistry and materials science where we are beginning to use mathematical models and simulation on supercomputers to reduce the amount of expensive and difficult experimentation.

Our own supercomputer, Mr. Chairman, I am very happy to say, which became operational in July of this year, is already valuable to us in this regard.

The engineering laboratory of the future will likely be altogether different from that of today. However, before that potential is fully realized, problems in evaluating parallel processing, software, and improved theoretical models must be solved.

In your letter, Mr. Chairman, you also expressed concern about our ability to attract technical staff. High quality, creative, scientists and engineers are critical to the National Bureau of Standards. Fortunately, NBS continues to benefit from many dedicated employees who commit their scientific careers in our laboratories. We must continue to recruit recent graduates with new skills and new ideas, as well as to train and retrain our staff to keep ahead of the fast rate of technological change.

In contrast to the satisfactory situation in physics and chemistry, we do face difficulties in recruiting and retaining experts in computer science, microelectronics, and manufacturing automation, because industry itself competes aggressively for these scarce skills. We do have better success with electrical engineers with about 5 years' experience after graduating—and I think we understand the reasons for that—but we do continue to have problems with computer scientists.

We will continue to use all techniques available to hire and retain quality technical staff—and here I'm not just talking about on a permanent basis. A temporary basis, a guest-worker basis, or research associate basis, any legal way we can get them, we're going to bring them to the Bureau to help do the job. One thing we shall always remember is that it is the opportunity to do interesting and challenging work that is the main motivator of the types of people we need and want at NBS to carry out our legislative mandate.

Thank you, Mr. Chairman. I'll be glad to answer questions.

[The prepared statement of Dr. Ambler follows:]

U.S. Department of Commerce
Statement of Ernest Ambler, Director
National Bureau of Standards
Before the Subcommittee on Science, Research and Technology
Committee on Science and Technology

October 2, 1985

Mr. Chairman and Members of the Subcommittee:

I am pleased to appear at these hearings to consider the future role and mission of the National Bureau of Standards (NBS). Accompanying me is my Deputy, Mr. Raymond G. Kammer.

The National Bureau of Standards has been fortunate in having had, since its foundation, a clear legislated mission. Our Organic Act has given a consistent direction to our institution and to us as managers; it has provided a sound basis for discussion of our programs, especially with this Subcommittee.

CONTINUING SUPPORT FOR INDUSTRY

Our efforts to assure continuing growth and strengthening of our economy through the application of science and technology to our industries have never been greater. Our interactions with industrial measurement users have always been strong, and they are growing stronger. Over the past five years, we have doubled participation in our Industrial Research Associate Program. We now have 200 researchers from private companies and other institutions working at NBS on areas of mutual interest--with their sponsors, not NBS, paying their salaries. Our guest worker program is up by more than 40 percent, to 540 researchers working at NBS--again without any payment to them by NBS.

Since 1980, the number of customers we are dealing with in our Standard Reference Materials Program has increased from about 15,000 to 25,000. During that same period, the number of customers using our calibration services has similarly grown from about 1500 to 4000.

Most dramatically, the estimated value of cost-sharing and assistance-in-kind by those who are interested in and need NBS research and services has increased 265 percent since 1980.

These are concrete measures of the value of NBS' work, of which I am proud.

For many years industrial and university research groups have made cooperative use of several unique facilities at NBS, with the results being in the public domain. Starting in May 1984, we began to allow access to some of our facilities for proprietary research by industrial firms. Already four major NBS facilities (the reactor, the environmental chamber, the combustion calorimeter, and the LINAC), have been used by five firms and many more inquiries have been received. We have found no conflict between this new approach and our existing responsibilities, and industry has already found this new arrangement very valuable.

The NBS role of providing accurate, reliable, scientific, and engineering measurements and data is one I do not need to belabor before this Committee. Most of you have taken part in previous hearings on NBS and many of you have visited NBS. You have been aware for some time of the importance of science and technology to U.S. industry and of NBS efforts to improve industrial competitiveness.

To begin my more detailed comments, let me go back to our last oversight hearing before this Subcommittee, the Review of the NBS Organic Act in June 1981. A concern expressed at that time by some of the witnesses was that NBS might be straying from its traditional mission of providing measurement and standards services--that we were being drawn or pushed into putting too much research attention on sophisticated science to the detriment of traditional services such as weights and measures support to state and local governments and calibration services for industrial users.

We must continually adjust the balance between providing measurement services for today's requirements and conducting research leading to new and improved measurement methods for tomorrow's needs. These next generation measurement methods become more important as U.S. industry deploys more high technology as a strategy to counter foreign competition.

Nevertheless, since your 1981 oversight hearings, NBS has given increased attention and allocated more resources to measurement services such as calibrations and weights and measures. Although the supervision of weights and measures operations must be carried out at the state level, we have worked closely with their association, the National Conference on Weights and Measures. Through a grant from NBS, the Conference is preparing a series of training modules to be used by inspectors to upgrade skills at the state and local level. The emphasis of the training is on modern electronic measurement equipment. We have also worked with the Conference to establish a national type evaluation program for commercial measuring equipment, so that approval by one state laboratory will be accepted by all states. NBS has already authorized laboratories in California, New York, and Ohio to carry out this service. Officials in the weights and measures community have expressed satisfaction with our increased support over the last few years.

We have also made significant improvements in our calibration services. We have improved technical documentation, increased our interaction with users, added 25 technicians for calibration support, and enhanced coordination with the Department of Defense. Both our FY 85 and FY 86 appropriations requests included additional increments for improved measurement services.

It is important to remember that NBS must respond to a wide spectrum of customers. These include industrial firms, individual scientists and engineers, other Federal agencies, and Federal, state and local regulatory officials particularly those responsible for public health and safety. To serve this broad array of customers, we must maintain a broad range of technical expertise and services.

As we move to meet the measurement demands of emerging high technology, as we must, we cannot abandon already established measurement services to industry. Indeed generally existing measurement services must be continually upgraded because demands for accuracy become more stringent; they do not go away.

Let me illustrate this with our experience in the electrical measurements area.

NBS has, since its inception, provided DC voltage measurement services to industry. Over the last 80 years, the level of accuracy needed by industry for routine operations has increased by a factor of 1000. NBS has responded to this changing requirement and now maintains voltage standards using a scientific discovery in superconductivity involving Josephson junctions, as opposed to traditional chemical standard cells. Soon we expect to provide a further improvement as a result of intensive research to overcome difficulties encountered in connecting some 1500 superconducting Josephson junctions in series.

At the same time, other types of electrical measurements have to be developed, their ranges extended and their levels of accuracy improved. Here we are talking about quantities such as current, resistance, capacitance, inductance, power, phase angle, power factor, conductivity and so on. These quantities must often be measured in magnitude over ranges of a billion or more, and not only for direct current but for alternating currents up to very high frequencies.

The users of these services range from manufacturers of high precision digital voltmeters to the users of watt-hour meters. All homeowners are very conscious of their utility bills. These bills are based on measurements traceable to NBS, as they have been for the past 85 years. The error allowed has been less than 1 percent. During the energy crisis in the early 1970's, we began to see demands for higher accuracy and a new series of electronic meters were developed. Especially demanding were the sellers and buyers of large quantities of power, such as aluminum and steel processing plants and the power companies themselves. Their accuracy requirements are now one hundred times higher than before the days of the oil embargo. Today $125 billion worth of electrical power is bought and sold in this country each year, and all transactions are traceable to NBS. An error of 1 percent in measurement translates to $1.25 billon.

As modern instrumentation came to rely on high speed digital signal techniques, the analog to digital converter became the heart of such instruments. We responded by providing a calibration service for these devices.

We developed and continue to upgrade a range of measurement services for electromagnetic quantities needed for radar and communications equipment, microwave radiation, and satellite communications; here I am speaking about quantities such as power, attentuation, noise, standing wave ratio, antenna gain, electrical field strengths, pulse shapes, and forms and so on. As an example of the effectiveness of our work, we have just helped the Navy save an estimated $6 million dollars in building and testing costs for the Aegis radar antennas by using a revolutionary new measurement method developed at NBS.

Now high speed communications are being carried along optical fibers as lightwave communications systems are being installed. In anticipation of these advances and the consequent new services we shall have to provide, we have begun research, under our Competence Program, to develop basic capabilities in lightwave communications.

Yet, these activities still leave some of our clients unsatisfied. Recently an industry/IEEE committee on microwave standards identified additional levels of accuracy in certain measurements that were required to enhance U.S. competitiveness in foreign markets. Microwave measurements are an area that we had well under control a number of years ago, but demands for higher accuracy have appeared that we cannot at present meet. We are already moving to respond, and a portion of the "Process and Quality Control" initiative in our FY 1986 appropriation will allow us to address these problems further.

In illustrating the breadth of the technical areas we must cover, I have been speaking only of electrical measurements. Yet in this area, 20 of the 99 industrial sectors representing more than 10 percent of GNP use these measurements in a significant way.

But measurements of all kinds are pervasive throughout industry. High-technology, high-growth-rate industries spend as much as 20 percent of their value-added on measurement related activities. Together we spend about $25 billion per year on medical diagnostic measurements. Industry as a whole is spending more than $163 billion annually on physical, chemical, and engineering measurements. Many types of measurements are made, each spanning many orders of magnitude, using numerous methods and types of measurements and all have to be uniform and accurate throughout the economy; all have to be referred to the national standards maintained and coordinated internationally by the National Bureau of Standards. This is a great responsibility, Mr. Chairman, and one to which the Director of NBS must always take very seriously; and believe me, I do.

FUTURE DIRECTIONS

You asked about what NBS is doing now to enable it over the next 15 years to continue its state-of-the-art research and standards leadership needed to help U.S. industry be competitive at home and abroad.

The future needs and directions for NBS programs are given in the Long Range Plan of the National Bureau of Standards soon to be released. I will send copies of this plan to members of this Subcommittee. As did our previous plans in 1980 and 1981, the 1985 plan presents the Bureau's analysis of future technologies and our response to them. Looking back, I feel we were able to plan and execute with great success. For example, we were able to get a timely start on such programs as microelectronics, automation, and robotics.

Our plan is based on a view of the future of U.S. industry and on the discoveries and developments we can expect in science and engineering. Let me summarize the main features of our latest Long Range Plan.

If U.S. industry is to achieve a competitive position in world markets based on the use of high technology, there must be a focus a more rapid conversion of research results into commercial products and on more efficient manufacturing and processing. The trend to increased automation will continue and spread as overhead functions such as ordering, production scheduling and inventory are integrate with design and manufacturing. This trend to automation will sprea to all industries. For example, the construction sector must use automation to overcome its low productivity gains and rising foreig competition; we already see automation in construction starting in Japan.

THE CHEMICAL INDUSTRY WHICH IS ALREADY HIGHLY AUTOMATED WILL BE FACED WITH COMPETITION FROM COUNTRIES WITH ACCESS TO CHEAPER ENERGY AND FEEDSTOCKS. IT WILL BE FACED ALSO WITH CONTINUED PUBLIC CONCERN ABOUT TOXIC BY-PRODUCTS. IT WILL LIKELY HAVE TO DEVELOP NEW PROCESSING TECHNOLOGIES (E.G., BIOPROCESSING) AND APPLY THEM TO LOW AND MEDIUM VALUE ADDED PRODUCTS AS WELL AS TO THOSE THAT ADD A HIGH VALUE.

LET ME BRIEFLY MENTION SOME TECHNICAL AREAS WE IDENTIFY FOR FUTURE GROWTH IN OUR PRESENT PLAN. DEPUTY SECRETARY BROWN HAS ALREADY DISCUSSED SOME OF THEM FROM HIS OWN BACKGROUND AND PERSPECTIVE.

IMPROVED PROCESS AND QUALITY CONTROL WILL HELP INDUSTRY INCREASE ITS PRODUCTIVITY AND ENHANCE ITS ABILITY TO EMBODY NEW TECHNOLOGY IN COMMERCIAL PRODUCTS AND PROCESSES. A COMMON THEME IS AUTOMATION AND THE MOVE FROM POST-PRODUCTION INSPECTION TO IN-PROCESS SENSING AND CONTROL.

Advanced materials will allow the design of entirely new products as well as improved performance of existing ones. NBS' top priority at present is to develop a national cold neutron research facility, which would be a world class research tool for advanced work in materials science by NBS, industry, and academia. Composite materials will be developed in greater variety for a wide range of applications and NBS is beginning to address that subject. Ceramics processing research is already underway at NBS. In the longer-term, an improved understanding of the fundamental structure-function relationships will allow a greater number of tailor-made materials to be developed.

Biotechnology advances will lead to new products and processes. Refocused NBS research is developing needed data and improved understanding of the relevant biochemical processes. The programs and priorities of NBS are clearly in line with the recommendations for Federal research of the Humphrey Panel of the Committee on Science and Engineering Public Policy of the National Academies of Sciences and Engineering. Effective bioprocessing measurements are needed to support the switch to the manufacture of chemicals, feedstocks, and materials by biochemical means.

Evaluated engineering data have become even more important for industries undergoing rapid technological change, particularly as engineering data bases become integrated into CAD and CAM systems. NBS is working closely with several industrial and professional groups in identifying, developing, and disseminating evaluated data bases in computer form.

Implementation of interface standards will help speed the effective interconnection of equipment into information networks. Integrated manufacturing systems, electronic mail, and remote computer data bases that characterize the future industrial and business world all depend directly on the ability to exchange data among differing hardware and software systems. The open systems interconnection approach of the International Standards Organization is designed to accomplish this,
but more testing and development will be needed before it can be fully implemented.

Optical communications will provide significant increases in speed, capacity, and reliability of communications and information processing over the next 15 years. This is creating a market with massive foreign competition from both Japan and Europe for optical fiber cables. This will be followed during the next decade by integrated optoelectronics that process an all-optical signal. Farther down the road may be a high capacity computer that operates at lightwave frequencies. For such lightwave technology to become commercial, a host of measurement, technical, and standards barriers must be overcome.

Supercomputers based on a very large number of parallel processors will allow advances in several research and industrial areas through much higher performance. We have already advanced considerably in areas ranging from aircraft design to basic chemistry and materials science where we are beginning to use mathematical models and simulation

ON SUPERCOMPUTERS TO REDUCE THE AMOUNT OF EXPENSIVE OR DIFFICULT EXPERIMENTATION. NBS' OWN SUPERCOMPUTER, WHICH BECAME OPERATIONAL IN JULY OF THIS YEAR, IS ALREADY VALUABLE TO US IN THIS REGARD. THE ENGINEERING LABORATORY OF THE FUTURE WILL LIKELY BE ALTOGETHER DIFFERENT FROM THAT OF TODAY. HOWEVER, BEFORE THAT POTENTIAL IS FULLY REALIZED, PROBLEMS IN EVALUATING PARALLEL PROCESSING, SOFTWARE, AND IMPROVED THEORETICAL MODELS MUST BE SOLVED.

IN ORDER TO ACCOMPLISH OUR OBJECTIVES BY DEVELOPING NEW SERVICES AND MAINTAINING EXISTING ONES, WE SHALL PUSH FOR INCREASED COOPERATION IN R&D BETWEEN INDUSTRY, GOVERNMENT, AND UNIVERSITIES. WE SHALL DEVELOP MORE EFFICIENT WAYS OF DISSEMINATING OUR SERVICES. (FOR EXAMPLE, WE NEED TO DEVELOP BETTER INTRINSIC TRANSPORT STANDARDS FOR CALIBRATIONS AND NEW ON-LINE DATA BASES FOR REFERENCE DATA.) WE SHALL CONTINUE TO ENCOURAGE THE ESTABLISHMENT AND IMPROVEMENT OF SECONDARY STANDARDS LABORATORIES, SUCH AS THOSE BELONGING TO THE NATIONAL CONFERENCE ON STANDARDS LABORATORIES AND THE NATIONAL CONFERENCE OF WEIGHTS AND MEASURES, AND PROVIDE ASSISTANCE TO THEM. WE SHALL CONTINUE TO PROJECT INTO THE FUTURE AND REFINE OUR PLANS SO THAT WE CAN ANTICIPATE AND MEET INDUSTRIAL DEMANDS IN A TIMELY FASHION.

STAFFING

High quality, creative, scientists and engineers are critical to NBS fulfilling its mission. Fortunately NBS continues to benefit from many dedicated employees who commit their scientific careers in our laboratories. We must continue to recruit recent graduates with new skills and new ideas, as well as train and retrain our staff to keep ahead of the fast rate of technological change.

In contrast to the satisfactory situation in Physics and Chemistry, we continue to face a special difficulty in recruiting and retaining experts in computer science, microelectronics, and manufacturing automation, because industry itself competes aggressively for these scarce skills. We do have better success with the electrical engineers about five years after graduation, but attracting computer scientists remains a problem. We will continue to use all techniques available to hire and retain a quality technical staff on a permanent, temporary, guest-worker, or research associate basis. And we shall always remember that it is the opportunity to do interesting and challenging work that is the main motivator of the types of staff NBS needs for carry out its legislated responsibilities.

Thank you, Mr. Chairman, I shall be happy to answer questions.

UNITED STATES DEPARTMENT OF COMMERCE
National Bureau of Standards
Gaithersburg, Maryland 20899
OFFICE OF THE DIRECTOR

JUNE 1985

ERNEST AMBLER, DIRECTOR

Dr. Ernest Ambler became the eighth Director of the National Bureau of Standards in February 1978. At the request of Secretary of Commerce Malcolm Baldrige, he has continued as Director for the Reagan Administration. Dr. Ambler joined NBS in 1953 and has worked throughout his career to make NBS an increasingly valuable scientific and technical resource for industry, business, government, education, and the public.

As Director of NBS, Dr. Ambler leads the Nation's measurement laboratory in the physical sciences and engineering. NBS directly supports the commerce, industry, and science of the Nation by producing and delivering measurement products and services. These products and services provide the basis for the exchange of goods, the accurate specification of products, quality control methods for production, and scientific advances. NBS contributes directly to the competitiveness of U.S. industry by maintaining and improving the Nation's measurement capabilities. The Bureau's headquarters are located in Gaithersburg, Maryland, with a second laboratory in Boulder, Colorado.

As a scientist, he has contributed directly to the state-of-the-art in measurement technology. His expertise in nuclear physics and cryogenics formed the basis in 1956 for a cooperative effort that disproved the law of parity conservation, a concept that nuclear scientists had adhered to for more than 30 years. This pioneering project confirmed experimentally the theoretical work of Nobel Prize winners T. D. Lee and C. N. Yang.

As an administrator, Dr. Ambler has helped guide Bureau operations and policies to improve the efficiency with which NBS fulfills its mission. His management responsibilities began in 1961 when he became Chief of the Cryogenic Physics Section. Four years later he was appointed Chief of the Inorganic Materials Division. In 1968, as Director of the Institute for Basic Standards, he assumed responsibility for directing the most basic of NBS research activities: developing and maintaining standard and measurement techniques for such quantities as length, mass, time and frequency, and temperature. He was appointed Deputy Director of NBS in 1973, and Acting Director in 1975.

Mr. Walgren. Thank you very much, Dr. Ambler.

You indicate that you are pretty comfortable with the basic Organic Act, as I gather, that was referred to. Could you just outline what its essence is right now and what some of the proposals for change in the Organic Act have been in recent suggestions, just to give us a little background on that question?

Dr. Ambler. Yes; there have been amendments to the Organic Act. I might say I was just delighted with the one that was recently made, which raised the level of the Director from a 5 to a 4. But generally speaking, the amendments are rather small of that kind, not sweeping changes into the substance of our basic mission.

The Bureau of Standards' Organic Act still, I think, its root and its core, and the way I think all directors interpreted it after a great deal of study, is not much different from what it was when it was written in 1901. It has been improved. And to explain what that is, to go to that time, we were industrializing at that time. The electric light and all kinds of technical things were happening. The face of the country was changing and people were starting to move off farms. The pulse of the economy was really moving, and people were beginning to realize that as all this was happening people were having to work together. They were having to plug things together and having to connect things together. There were things——

Mr. Boehlert. Excuse me, Doctor. Could you speak into the microphone?

Dr. Ambler. Oh, excuse me.

Mr. Boehlert. I'd love to hear what you have to say.

Dr. Ambler. I was saying that as all this was happening, people were starting to have to work together. They were starting to have to plug things in together and communicate with each other and exchange—you know, things they manufacture and mass production and all of that was taking place. And standards became very important, and measurements became a tremendously important part of it.

We weren't the only ones to realize that. It was in the space of 3 years that Germany, the United Kingdom, and several other countries did the same thing, because they were in the same process of change.

There needs to be a national focus where people can go to find out whether a technical situation, which all depends on measurement ultimately—people don't realize how many measurements are made. We all make measurements. Everybody makes measurements. It all has to tie together. Somebody has to be there to say it's right, it's wrong, and to provide assistance to those who perhaps don't have all the technical expertise to develop it themselves, get it right and get it uniform and get it internationally compatible. That's the basis.

We're talking—today it's not very different, and in a way, we're in an equal situation of change. The pressures are different. I mean, we had everything going for us then, and now our backs are to the wall a little bit. But I think the spirit is there and the Bureau of Standards is needed as never before.

The thing that's changed is not the Organic Act and the spirit behind the Organic Act. It's technology. It's grown, it's mushroomed. I mean, it's more important than it's ever been. And we have to do much more than the committee that sat in the House and drafted that bill, where they started out by saying in the committee report there can be no more useful service to industry, instrument manufacturers, et cetera, et cetera, than the creation of this institution.

And today, chemical measurements, it's engineering test procedures, it's computer interfaces, and on it goes. And still the same theme. Computer interfaces, computers have got to talk to each other; they've got to have protocols, standards. It's the same thing.

Mr. WALGREN. Let me ask, then, if you would just briefly mention some of the suggestions that have been made in the recent past about changing the Organic Act or adding to its function. I think I am revealing my own lack of background here, but I think it is an important subject, and I thought you might be the right place to get the answer from.

Dr. AMBLER. Well, I don't know I can recall specifically what you want. I would be glad to supply it for the record. The thing I can say on it—I don't want to go on too much here—but I think I have testified a number of times on the Organic Act, and I think Mr. Brown probably has been at all of them, and I think he might agree that I have never been too enthusiastic for doing much to the Organic Act.

It has such broad responsibilities—it's a dandy piece of legislation.

Mr. WALGREN. Well, let me ask you this, then. What is the authority in the act to do the pure innovative basic research in measurement that has attracted a lot of our attention lately? Where is the support for that in the act that gives you that mission?

Dr. AMBLER. I'm not sure there's anywhere in the act that speaks to basic research. I'm sure it's in the Act that we have to discharge these functions at the highest levels of accuracy, or the highest levels of accuracy attainable.

Mr. WALGREN. But let me ask you this. Are we then in a period when some people are asking for more for the Bureau of Standards than present ways enable us to ask that organization to push the knowledge, other than to do it with excellence or with quality or something like that? I had in my mind this concept of sure, two people brought you two plugs in 1901 and asked does one fit in the other, and you are able to say yes or no. But what about people who come to you and say we've got to find a way now of taking electrical impulses from one framework and transferring them into another framework, and somehow that interface has to work. I would gather that that's not beyond what some of us conceive the Bureau might be interested in, as a laboratory involved in basic research in many ways. And yet, are you sufficiently pushed in that direction by our legislative understanding of what you do?

Dr. AMBLER. Well, I'm not sure about whether we're pushed in that way. I can assure you that in our reading of the Organic Act, in our understanding of the Bureau of Standards in the very way we feel about it, we know we have to be doing research, to anticipate, and we do. We are using the competence money for that very purpose. You can look at our plans, you can look at the way we analyze the future, and we do do the long-range research. I'm not saying we do it all, all we should, but we are able to do that. I know of no restriction—I have never felt the slightest inhibition about starting a research project where I felt out of it was going to come a future measurement requirement.

Mr. Walgren. We have this strange dichotomy here; yesterday one of the witnesses was saying the Bureau of Standards is very misunderstood, and it should be understood as an agency that does research. And yet, I'm just wondering, although you have not felt any inhibitions, I wonder whether our system gives you the proper encouragement supported by resources, not only so you don't feel any inhibitions, but so that the Bureau actually moves with as much initiative as could be brought to that area, or should be brought to that area.

Dr. Ambler. Well, resources are another matter. No, I would like to continue this discussion without talking about resources because that gets into budgets and this is really a policy hearing. If you would allow that. Then I find that our oversight committees in both the House and the Senate are very encouraging and very understanding. I think we have excellent communications with them, particularly the last 5 years.

I do think it's generally true, not only as we talk to the members but the staff—we talk to people in the administration, we talk to anybody outside the Bureau of Standards—I do think it's true that it is much easier to get some understanding for something that's new and glamorous. You can get publicity for space beads. You understand ceramics. But if I were to tell you about some area of electrical measurements, that might be, you know, a little hard for me to get across.

Also, I do think that—you know, we have discussed at previous hearings the additional assignments we have got in legislation—I do think there is a tendency, because the Bureau of Standards has the capabilities that it has, to use it for things that really don't fit too well with the Organic Act.

Mr. Walgren. I guess one of the frustrations I have is that this may be true of the leadership of the science committees—and this committee has been very supportive of the Bureau, and has perhaps the best concept of the Bureau—but the truth is we almost lost control of that bill on the floor last year. I suppose maybe it could have been corrected in the Senate; but I can tell you pointblank that I didn't sense a lot of understanding of the Bureau among other Members of Congress who are not on the Science Committee. Given the limitations of our own process here, there are limitations on our ability to transfuse that into other Members that are not thinking of the Bureau.

I guess that's why I really raise this, because I think there is sort of a fundamental lack of appreciation of what the Bureau can really contribute. I try to expound to other Members about the potential of the Bureau.

That's why I guess I'm brought back to this Organic Act. I wish in a way that we had more clear beacons, that we weren't doing things under an implied authority, or because we didn't feel inhibitions. I wish we could take the structure and flat out say, this is what we want this agency to do and by gosh, there they go and they're doing it.

Well, we have the second bells. I'm afraid we have a vote over on the floor that's probably going to take us about 15 minutes to respond to it. I've sort of taken more than my share of the time, Dr. Ambler, so if I could ask you to suspend while we go respond to that call, then we can come back, OK?

Dr. AMBLER. OK.

Mr. WALGREN. Thank you.

[Whereupon, the subcommittee was in recess.]

Mr. WALGREN. I apologize for the interruption. Please continue with the thought that we left on.

Dr. AMBLER. Well, I've had a little chance to think about your question. I imagine that one of the things that might concern you is whether we have the authority to do the necessary long-range research or basic research.

I think the answer is that it's not explicit in the Organic Act. I believe it's implicit. The Organic Act as a whole is a piece of legislation that authorizes us to do things. I see absolutely nothing wrong with language that authorizes or mandates that we do long-range research in the pursuit of our mission. I don't think it should be an open-ended authority to do basic research of any kind, shape or color. I think it should be the pursuit of our legislated mission.

So, with that, I don't think I have ever felt that the absence of those things has been a tremendous handicap, but if it's useful to you, Mr. Chairman, and the difficulties that you had in explaining to other Members, I'm all for it.

Mr. WALGREN. Well, I just feel it's important to raise the subject with you, Dr. Ambler. It would be surprising if something written in 1901 were able to support, to the degree that it should be supported, the role of the laboratory in 1985 and the year 2000, particularly when we are realizing more and more that it is the Government that is funding much of the basic research that we're relying on. And just looking at the act, there are several functions that you're directed to be involved in. One is the development of standards of measurement and the provisions of means and methods for making measurements. Now, that covers a lot of ground.

The next directive I see is the development of methods for testing materials. Well, that covers some ground, too.

I just wonder whether the Bureau is appreciated for what its contributions can be. All the contributions that I hear cited as some of the really good things that can happen seem to be under the implied umbrella rather than the explicit function of a Government agency—deliberately undertaken with knowledge aforethought about the benefit and the importance of Government pursuing that particular role.

Well, let me recognize Mr. Boehlert at this point.

Mr. BOEHLERT. Thank you very much, Mr. Chairman.

Dr. Ambler, yesterday at the hearing, Dr. Branscomb expressed concern that approximately 50 percent of the Bureau's funding comes from other than appropriated sources and that this is a very high percentage and it seems to be on the increase, and it might be compromising your independence and neutrality.

Is that something that concerns you? Would you comment on that?

Dr. AMBLER. Yes, it is something I follow very closely. I cannot say I am terribly concerned about it at the present time. It is 50 percent of the congressional appropriation. It's 30—if we look at the total budget, it's about 35 percent. We have thought about this often at the Bureau of Standards as to what's about right, and we generally come out around 30, 35 percent. So it is not hugely out of line.

I have never felt it's really a problem. You know, I think the thing for you to look at, for me to look at, is, are we taking the kind of money that we shouldn't be taking? Are we taking money that's turning us into a job shop? Are we doing something we shouldn't be doing? Or are we taking money that is enabling us to do the kinds of things that we do without appropriations, except that they are very specific to a given agency because they're paying for them? I think most of them are.

And, you know, we talked before about the way the Bureau of Standards supports the economy and how everybody is for supporting industry and the economy, and the Bureau, with all national labs, being right there with the right mission at the right time, and we do have some difficulties that we're all aware of. But I'll tell you, if I can do that mission, I'll get money any way I legally can. I'll get guest-workers, I'll get temporary workers, I'll get industrial researchers, I'll get it any way I can to get that mission done.

Mr. BOEHLERT. Well, you're having a hard time getting money from the administration. How do you retain—what's the morale status at the Bureau?

Dr. AMBLER. It's good. You could have asked Bill Slichter yesterday, who is head of our—we used to call them evaluation panels—boards of assessment we call them now. But these people are 15 committees that come every year and go down into the organization talking to me. They report uniformly that morale is good.

I have asked myself why is it so good, you know, because I would like to think maybe I had something to do with it. But I've come up with a couple of things. I think, first of all, people do understand they've got a great mission and they are very excited about their work. I think they went through this period 2 years ago when jobs were very scarce, you know, for scientists and engineers and they were damned glad they had a job. They just got on with their work and they felt the best thing——

Mr. BOEHLERT. Those days are over, though.

Dr. AMBLER. Those days are over, but—there were two things that this committee did that I think has really had a profound effect. One is starting the competence program, building up that fund so that they can compete for the long-range research money, and the other was the equipment modernization program that was completed a number of years ago. That's about what we came up with for the reasons that morale is so high.

I think there's a feeling also that, generally speaking, we all appreciate the feelings, as they read reports of hearings before this committee or in the Senate, in interactions with the Commerce Department, with Mr. Baldrige. We get very strong—and the President's science advisor.

Mr. BOEHLERT. But, you know, you can look ahead, and around budget time you must get palpitations of the heart. You can almost forecast what the next budget is going to say about NBS and more recommended rather substantial cuts, and this committee will stand by you because we appreciate you. Then we're going to have the same battle on the floor trying to get other people to focus on what NBS is all about. The chairman made reference to that in his remarks. It's an uphill battle.

How do you recruit? I mean, it must be tough. It's a very competitive world out there, and scientists and engineers have a lot of offers. Is your recruiting program suffering because of your underappreciation by maybe OMB or the big house down on Pennsylvania Avenue? Are you getting the talent that you want when you have vacancies?

Dr. AMBLER. Well, some areas are difficult, perhaps because of shortages more than anything else. I mentioned them in my testimony. There is this latest restriction, the GS–11 through 15 hiring restriction, that I guess you've heard about—and I think Mr. Brown mentioned it yesterday.

Mr. BOEHLERT. That has to pose a real problem for you.

Dr. AMBLER. This is a serious problem, and the Department understands it and they're trying to do something about it.

The crazy thing about the whole thing, it was never intended to apply to science and technical people. All the new people we were recruiting in that bracket——

Mr. BOEHLERT. Didn't we try last year to exempt you from that in some way, and we were told we couldn't do it?

Mr. KAMMER. I don't know.

Mr. BOEHLERT. At least we're trying our hearts out——

Dr. AMBLER. I think it headed toward middle management, you know, the packing of administrative offices, something like that. It wasn't intended, you know, in its form that came out of OMB, I guess, to be into nonmanagers. Bang, it hits us right in the area where we recruit our young talent.

Mr. BOEHLERT. One other question. I have some more, but I will submit them to you for your response at a later date. But this is one that is of particular interest, as you well know, to this committee.

In the last 3 years the administration has proposed the elimination of the fire research and building research programs, and also severe cuts in the Computer Institute budgets, yet strong bipartisan support, not just here but in the Congress in general kept these programs alive. What effect has this had on the Bureau and on these programs?

Dr. AMBLER. Well, it's meant that the people in the fire and building and ICST have sort of been——

Mr. BOEHLERT. Could you grab that microphone, please?

Dr. AMBLER. Yes. It's meant that the people in the fire, building, and ICST programs have sort of been waiting for the other shoe to drop.

Mr. BOEHLERT. Are they bailing out?

Dr. AMBLER. I don't think so, no.

Mr. BOEHLERT. Good.

Dr. AMBLER. I sort of figure they think it's not going to happen, I guess, so it doesn't get to them as much as it might. I mean, this situation, as you point out, has been there 3 years, going on 4. I hope I've been able to, every time I've come up here, to defend the President's budget and the position, but it isn't a budget hearing, it's a policy hearing, so maybe I can say this, that I'm beginning to feel, and maybe the Bureau is, it's beginning to have some effect on us finally and that I'm in a nutcracker. I've been in a nutcracker for 3 years and it looks like I'm going to be in a nutcrack for 4 years.

It's very difficult. The positions are polarized. The issue, when you come right down to the basics, is public safety versus the U.S. economy and support for industry. What a hell of a choice for anybody to make.

Mr. BOEHLERT. We're talking about the petty cash fund.

Dr. AMBLER. Beg pardon?

Mr. BOEHLERT. We're talking about the petty cash fund. I mean, you know, we're not talking about big dollars.

Dr. AMBLER. But I'm talking—you're asking isn't this going to have an effect. I think it is. I don't think it's on morale, but, you know, it is on the management. It is on me a little bit personally, too.

Mr. BOEHLERT. Sure.

Dr. AMBLER. You know, I'm feeling some things that I never felt before. But I was heartened. I got a report on the hearing yesterday and I was heartened, because I understand for the first time there was talk of some kind of compromise, and I didn't start this and I'm not one to settle it. It's got to be settled at high policy levels.

Mr. BOEHLERT. We'll take hope at——

Dr. AMBLER. Sure, if there's a compromise, so we can put this behind us, boy, I'm all for it and I will and my staff will work our butts off to try to provide facts and figures, so that——

Mr. BOEHLERT. Don't give up. Take hope, because for 3 consecutive years the administration has tried to eliminate the Economic Development Administration, and they tried it again this year, and for 3 consecutive years we said, on a bipartisan basis, by overwhelming votes, no, you can't do it. I'm told, from a very reliable source, they gave up the battle and are going to try to find something else. I hope it isn't further cuts in NBS.

Thank you very much.

Dr. AMBLER. Thank you, sir.

Mr. WALGREN. Mr. Brown.

Mr. BROWN. Dr. Ambler, I've been going over the Organic Act, and I think you're correct, that it's a very broad and comprehensive act which undoubtedly has the seeds of at least all of the authorities the Bureau needs. In fact, if we were doing it over again today, we probably wouldn't give you so much authority as included in the act. But there is a little editing that needs to be done. I'm not going to ask you to respond in detail now, but I think the committee might like to have your staff look at it from that standpoint. And let me just give you some illustrations of what I'm talking about.

You have, for example, categorical authority to engage in the study and improvement of instruments and methods of measurement, and then right following that, investigation and testing of railroad track scales, elevator scales, and other scales used in weighing. That used to be, 80 years ago, extremely important, but today it's just a minor aspect of your general authority to engage in the development of weights and measures, I would assume. That's one example of what I would consider an editing thing.

There's a more serious editing problem in that you have several paragraphs here that authorize you to deal with the broadcasting of radio signals, the investigation of conditions which affect the transmission of radio waves, the compilation and distribution of information on the transmission of radio waves. There's no reference, however, to radar, to television, to ultra-high-frequency transmissions, any of those things, and there's nothing on many of your major programs, although they could be assumed. There is nothing on automation, on robotics, on fiber optics, on biotechnology, on microelectronics, the things that we are all very proud of what you're doing and which could be subsumed under other authority. In fact, in connection with, say, the radio signals thing. That merely ought to be made into electromagnetic radiation rather than radio waves and you're covered. But they didn't know about radar when this was written. They didn't know about television when this was written. There's nothing in here about computer standardization and the things that you're doing.

There is a very extensive section added years later on the Fire Research Center, for example, much more detailed than it probably needs to be compared with what is in here for some other things. But I consider that to be an editing job more than anything else.

I would like to ask you if you perhaps couldn't have someone in your staff at least go through the exercise of looking at it from that standpoint. We might not want to change it because, of course, when you change the Organic Act, you open it up to a lot of nuts here in Congress who might want to do something drastic. But it would be an interesting exercise, it seems to me, sort of an editorial modernization more than anything else.

Dr. AMBLER. I think you're absolutely right. We'll take a look at it and maybe draft something and let you take a look at it.

Mr. BROWN. All right.

Now, let me ask you just one other question. We had this discussion yesterday with the Under Secretary with regard to the fire and the building program. The building program is not specifically set forth here, except in terms of your general responsibility for building standards and so forth, which I think clearly covers it. The fire is covered in much more detail. But the wording of the fire program allows you to either do research or to contract for research in this connection.

What we discussed with the Under Secretary was, if they're so anxious to have the Bureau shed this, why couldn't we consider something like NSF is doing in establishing engineering research centers around the country, have you establish a fire engineering research program, and under the same conditions which NSF does, which is a 5-year phase out funding sort of a situation, in which the winner of the competition agrees to develop permanent funding for it in recognition of the *x* millions of dollars in startup funding that would be given to them in order to get the program moving.

I think you have authority to do that now if you wanted to do that.

Dr. AMBLER. Yes, the grants programs—we do have a grants program, one of the few areas in which we do. And, of course, that was transferred to us from the National Science Foundation.

Mr. BROWN. I want to see the Bureau continue, but I don't want to have this budget impasse which keeps you from getting other new, innovative programs as a sacrifice to the fire program, you know, in which we insist that we fund it and then we cut the other new starts in order to produce enough money to fund it. That's not sensible. We ought to be able to work that out in some reasonable way.

Dr. AMBLER. Well, if I'm asked to work with people in authority on——

Mr. BROWN. I understand.

Dr. AMBLER [continuing]. On this side of Constitution Avenue and the other, to work out some kind of compromise—

Mr. BROWN. We suggested it to the Under Secretary. I think he's going to consider it, and I think we might want to make that kind of recommendation from the committee, despite the fact that we don't want to give up the program. But if it's permanently established as a national center under the auspices of a leading university with, say, 5-year funding to get it started from the Bureau or someplace else in the Government, it might be a reasonable compromise and allow us to expand then into some of the other areas which the administration, to their credit, is supporting very strongly.

Dr. AMBLER. Yes. I would very much like it to happen that we are requested to do something along these lines, rather than doing it on our own initiative.

Mr. BROWN. I have no further questions, Mr. Chairman.

Mr. WALGREN. Thank you, Mr. Brown.

We appreciate your testimony, Dr. Ambler, and we look forward to working on this with you in some way. We now know that you're on the other end of the Metro line, which really should make you more accessible to all Members of Congress than you have been in the past. I hope maybe we can get some more real direct daily contact with the Bureau than I personally have had in the past and perhaps can be of some help in that process.

Dr. AMBLER. Yes, sir; and we run a shuttle bus from the Metro station at Shady Grove, so anytime anybody wants to come, give us a call and you'll be met. It's very smooth. We use it very much. It has been great. The Metro line has simplified it for us.

Mr. WALGREN. Do you have any thought of making the area that your ducks are in out there open to the public on the weekends?

Dr. AMBLER. We haven't done that because we think we might get a little crowded and we are custodians of Federal property. However, for our friends who have sons and daughters who like fishing or running or jogging or riding a bike, just give me a call and it can be arranged.

Mr. WALGREN. I want to compliment you on your security. You're locked up tighter than a drum out there on Saturdays and Sundays. None is getting into those grounds who didn't make prior arrangements, that's for sure.

Dr. AMBLER. Right.

Mr. WALGREN. OK. Thank you very much. We appreciate your coming.

Mr. WALGREN. The next panel is Dr. John Toll, who serves as president of the University of Maryland, and Dr. Neal Lane, who is the chancellor at the University of Colorado. We understand Dr. Lane has to go back out at about 4:20 and we don't want to keep you. We'll make sure you make that plane.

Dr. TOLL. I would be glad to yield to Dr. Lane first.

Mr. WALGREN. So why don't we proceed with you, Dr. Lane.

STATEMENTS OF DR. NEAL F. LANE, CHANCELLOR, UNIVERSITY OF COLORADO AT COLORADO SPRINGS; AND DR. JOHN S. TOLL, PRESIDENT, UNIVERSITY OF MARYLAND

Dr. LANE. Thank you, Mr. Chairman, and President Toll, for this change in the order. I appreciate it. I bring you greetings from Colorado and I'm hoping to get back there via Chicago or Stapleton Airport or someplace or other. Duty calls.

My name is Neal Lane. I am chancellor of the University of Colorado at Colorado Springs. I will try to keep my remarks brief and ask if the written testimony can be included in the record.

I am very pleased—indeed, excited—to have an opportunity to appear before you today to talk about a unique and, I think, a quite outstanding example of cooperation between the National Bureau of Standards and higher education. President Toll I know will talk about a number of such interactions. I will concentrate on just one, namely, the Joint Institute for Laboratory Astrophysics, which is located on the University of Colorado campus in Boulder. Throughout my own career I have viewed this joint institute—it's called JILA by friendly folks around the world—I have viewed this from several perspectives: as a theoretical atomic and molecular physicist, as a chairman of the National Academy of Science's NRC Evaluation Panel for a number of years, and finally, as chancellor of one of the University of Colorado campuses.

I have watched the institute develop and mature and spin off its scientific products in a variety of ways for 20 years or so, so I am very pleased to talk to you about it today.

JILA is a world class cooperative venture between the National Bureau of Standards and the University of Colorado. It was formed in 1962 and it operates under a memorandum of understanding, and has done so since its founding. Although it was created as a spinoff of the space program, it has evolved over the years into a world center—I would say the world center—in the atomic and molecular sciences, and in closely related scientific disciplines: for example, laser physics and laser development technology, precision measurement, physics and chemistry of atmospheres of the Earth, stars, planets, geophysics, astrophysics, and the study of plasmas, here on Earth or elsewhere.

JILA is located in its own facility. It's on the University of Colorado campus in the physics complex. It has a senior staff of 32 or so senior scientists. Ten of those are temporary, the rest permanent scientists; and of the 22 permanent fellows who govern the institute, 14 are Bureau employees and 8 are full-time faculty of the University of Colorado.

The approximately 10 visiting fellows spend up to a year carrying out independent and cooperative research in residence at JILA. Many of them bring their own support, or at least partial support.

The selection process for the visiting fellows is highly competitive. About 1 in 4 are accepted in a given year, and in all, over 200 have come to JILA from over 29 countries, as well as the United States. This visiting fellows program has always been viewed as a key, and some would say the key, to the success of the joint institute, and that opinion is held by the permanent members of the institute. And in times of budget squeezes—and there have been many—the visiting fellows program has been protected. It is now as strong as it has ever been in the 23-year history of the organization.

Well, now one might ask who cares if we have a center of atomic and molecular sciences in the United States, and if we do need one, why does the Bureau have to be involved and why does it need to be on a university campus? Let me address each of these very quickly.

First, it is an accident of nature, or maybe a grand design, that at the temperatures and pressures we work at in our everyday world, atoms and molecules are the important constituents. So the basic physical properties of atoms and molecules determine biological processes, absorption and emission of light, including laser phenomena, combustion of materials, the properties of new materials, confinement in fusion plasmas, and atmospheric phenomena, including those which directly relate to communications, satellite, and shuttle control, particle beam propagation through the atmosphere, air pollution, and other important atmospheric phenomena or activities.

The things that we care most about, and that most influence our quality of life, depend intimately on the basic properties of atoms and molecules. It's vital that we have a center, a first-class center—indeed, I think we should have more than one—that emphasize atomic and molecular sciences.

Why should the Bureau be involved? Well, it is simply the case that the mission of the Bureau as it relates to developing new basic technologies, standards, measurement techniques, demands that it continue to push the state of knowledge, in my view, about new methods of accurately measuring time and distance and determining the properties of materials.

At JILA, the Bureau is able to guide the direction of basic research to these ends. In fact, a division, consisting of only 22 people, the Quantum Physics Division of the National Bureau of Standards, influences and participates directly in the research of an institute of over 200 people, including 166 scientists.

This year, just to give you an example, one of the world's top molecular spectroscopists, laser spectroscopists, collaborated with one of the permanent NBS scientists at JILA to develop a new laser scheme which they used to cool and to stop a beam of sodium atoms. Well, sodium atoms aren't all that exciting, I guess, but it's hard to stop a sodium atom—it's hard to stop any kind of atom. They're neutral particles; they have no net charge; they're not really controllable by electric and magnetic fields. Indeed, it is hard to know how to stop sodium atoms. How do they do it? Well, they do it by directing a beam of laser light, radiation, at the atom; the atom absorbs the light of a particular frequency; then energy and momentum are transferred to the atom, slows it down, eventually stopping it.

That kind of control has broad implications for future frequency standards and may lead to sensitive tests of physical principles as well—for example, quantum electrodynamics. There are other examples given in the written testimony. So important things are done at JILA, and these things are relevant to the Bureau's mission.

Why do we have to do this in a university environment, or in cooperation with the university? Well, my feeling is that a university, a fine university, is a magnet for first class research scientists, because it's a free environment for the discovery and exchange of knowledge. That's what goes on in universities; that's what the university is all about. Moreover, the students who flow through the laboratory, a laboratory like JILA, bring enthusiasm, they bring a capacity for hard work, they bring a kind of naive curiosity. They ask dumb questions that aren't so dumb, and sometimes those questions lead to major breakthroughs.

Of the 56 doctoral students at work in JILA, 31 are supervised by Bureau scientists. These students work long, exhausting hours for very little pay, as you may recall, and they work on research projects that directly relate to the Bureau's mission. Moreover, when they leave as Ph.D. scientists, they leave with an expertise, and they leave with an interest in problems that are important to the Nation. That's not true of all of our Ph.D. students.

JILA is also a first choice of many postdoctoral research students around the world, and of the 41 postdoctoral students working at JILA, 28 work with Bureau scientists.

One of the unique attractions of JILA, in my view—and I believe it's a major strength—is the large concentration of scientific talent in an important field like atomic and molecular science which neither institution probably could justify on its own. For example, the chemistry department at the University of Colorado in Boulder has 18 full professors to cover five fields of chemistry, in which chemical physics, for example, is only one area. Yet in JILA alone, between the University and the Bureau, there are four senior scientists in chemical physics and seven in a very closely related field or fields of atomic and molecular science.

If graduate students and postdocs are included in all of this, you have 100 researchers in this very vital field, and to my knowledge, this is the only such concentration in the country. They are able to collaborate, exchange ideas, and attract visiting scientists to work with them from all over the world.

I think it is widely acknowledged that JILA is a marvelous success story. However, the success is not easily achieved. As I indicated earlier, I have watched it for 20 years. I was a visiting fellow in 1965 and again in 1975. I followed the evolution of that institute as it has responded to new opportunities and to shifting pressures. Its success can be attributed, I think, to a consistent pattern of excellence in the hiring of personnel, the choosing of research problems, and the management of resources, and finally—and I would like to emphasize—to the continued vitality and prestige of the visiting scientist program.

In closing, I am tempted to say JILA is a model and that it can be replicated at many institutions in cooperation with several agencies, the Government. Basically, I do believe that. However, cooperation is not so easy to make happen. Money alone doesn't do it. Money helps do it. Although the United States possess outstanding universities and Government and industrial laboratories, cooperation is not, in my view, particularly good—with some important exceptions, such as I referred to and that I think President Toll will discuss here today.

And while the U.S. research scientists are among the most creative and productive in the world, the scientific infrastructure in this country is poor. We have no mechanism for replacing aging facilities in the universities, and we have insufficient funds for new equipment, maintenance of the equipment, and in many instances even for the formal research operations. And, of course, there is no national plan for science.

Well, the young people feel this. Many of the young people know this, and it is increasingly difficult to convince them, the brightest and best of them, to choose research careers for their life's investment of time, energy, and knowledge.

An institute like JILA can provide a focus of excellence, a concentration of people and facilities, that will ensure the continued vitality and the high performance standards of important fields like atomic and molecular science that are valuable for their practical as well as their fundamental impact and contributions to knowledge. And such centers of excellence in the university will serve as intellectual magnets, and they will help draw the most outstanding young people back into these challenging professions. Our Nation needs these young people. I think it needs them desperately.

Therefore, my request to you today, gentlemen, is simply to ensure that the National Bureau of Standards has the proper level of support and the proper balance of responsibilities that will permit JILA to remain excellent and will permit other similar centers of excellence to develop.

I agree with what President Toll has said in his written testimony, and I think he will probably repeat it here—and I apologize to him for mentioning it in advance—I feel the Bureau will become increasingly important, its mission increasingly more complex, because of the technical nature of our society.

Second, I feel the core support for the Bureau needs to be increased so that there is less dependence on external sources of funding. I would restrict that remark to my knowledge, which is primarily the Joint Institute of Laboratory Astrophysics, but it shares the same ratio; approximately half of the activities of JILA are funded from sources outside the National Bureau of Standards.

And finally, the Bureau must be able to compete for the best scientists in the country, so it must be able to provide the facilities and the working environment that will attract such people. At the Joint Institute of Laboratory Astrophysics one finds such an environment, and it does attract the very best. So please help the

Bureau remain strong and help us to have many more successes like JILA.

Thank you, Mr. Chairman.

[The prepared statement of Dr. Lane follows:]

Testimony of

Professor Neal F. Lane

Chancellor

University of Colorado at Colorado Springs

Mr. Chairman and Members of the Subcommittee:

Thank you very much for the opportunity to appear before you today and to address in particular some of the exciting opportunities for collaboration between the National Bureau of Standards and the University community. Dr. John Toll, President of the University of Maryland, has already given you an excellent overview of the way in which NBS cooperates with universities through grants, postdoctoral research associates and visiting professors, and he has summarized the productive interactions between NBS and the University of Maryland. I will therefore direct my remarks to one specific type of cooperative effort and the unique opportunities I believe it offers both partners for conducting the kind of long-term, high-risk research on which the Bureau's mission ultimately depends.

In 1962 the Bureau of Standards and the University of Colorado embarked on an entirely new kind of Government and University collaboration when they established a Joint Institute for Laboratory Astrophysics (JILA) on the University campus in Boulder. Supported alike by both institutions, JILA operates under a Memorandum of Understanding clearly setting out the responsibilities of each partner. This distinguishes it from the more usual type of academic research center that is funded by a combination of grants to individual faculty, and from the Federally funded laboratories supported by particular Government agencies and managed under contract by a university.

A direct outgrowth of the national space program in the early postwar period, JILA was formed in response to a report of the Space Science Board of the National Academy of Sciences. That report pointed to serious gaps in our basic understanding of the behavior of atoms and molecules in terrestrial, planetary, solar and stellar atmospheres. The unifying theme for the Institute therefore became the physics of gaseous atmospheres. Since then, however, JILA has responded to changing national needs and to the requirements of its parent organizations. Thus the Institute has become a world leader not only in atomic and molecular science and astrophysics but also in precision measurement, laser physics, and certain areas of geophysics.

My own experience of JILA has been obtained from three different points of view. First, as a theoretical atomic and molecular physicist, I have interacted professionally with JILA scientists for almost twenty years. (Indeed there are few scientists in my field who have not at one time or another been influenced by the work and scientists in JILA). Second, as Chairman of the National Academy of Sciences Evaluation Panel for JILA, I became increasingly aware of the unique contributions the Institute makes to the Bureau's mission. And finally, as Chancellor of the University of Colorado at Colorado Springs, I have come to appreciate the many ways in which association benefits the University and the State of Colorado.

Let me first tell you something about how JILA operates and then discuss why I believe it has been so uniquely successful. The Institute is located on the University of Colorado campus in Boulder, in a building constructed specifically for its use in the mid-1960s as part of the main physics complex. The senior staff is made up of about two-thirds permanent scientists and one third visitors. The permanent scientists or "Fellows", of which there are currently 22, form a governing body that sets policy, subject to review by the Director of NBS and the President of the University. A Chairman, elected every two years by the Fellows, has much the same role as the chairman of an academic department. Assisted by an executive committee, he is responsible for operating the Institute within the policies set out by the Fellows. Of the 22 Fellows, 14 are Bureau employees and 8 are fulltime faculty members from the Departments of Physics, Chemistry, and Astrophysical, Planetary and Atmospheric Sciences. Although these scientists work side by side, sharing facilities and responsibility for the success of the Institute, each remains officially responsible to his respective employer, NBS and its Director in one case, the University and the academic department in the other. The Visiting Fellows, of which there are approximately 10 each year, spend up to twelve months at JILA working on their own research and collaborating with other JILA scientists.

Why does the Bureau, a mission oriented agency with a hierarchical management structure, value its participation in an essentially academic program organized in a collegiate style? The answer is that in order to fulfill its mission of providing the Nation with a uniform basis for physical measurement, NBS must first and foremost be a research institution. The quality of its services stems directly from the breadth, vigor, and excellence of its scientific research base. The standards, measurements and data it provides are credible only to the extent that they are based on the best scientific and technical judgement available. NBS, like any vital scientific laboratory, must be permeated by an intellectual spirit of inquiry that only basic researchers of high caliber at the forefront of science can provide.

JILA is one means of furnishing the highly creative atmosphere necessary to attract, retain and support such scientists. The scientific stimulation provided by the University faculty, and by the constantly changing postdoctoral research associates and graduate students, would in itself justify the Bureau's participation the Institute. Such a flow-through of young talent is not readily available in the more usual type of government laboratory. Through their adjoint faculty appointments, NBS scientists at JILA have both the opportunity and responsibility to teach courses and participate in other faculty activities. This gives them access to graduate and undergraduate students, some of whom become interested in pursuing research directed toward NBS goals. Of 56 doctoral graduate students in JILA, 31 are supervised in their research by NBS scientists; of 41 postdoctoral research associates, 28 work with NBS scientists. Some have subsequently joined NBS and now occupy positions of leadership; others are carrying the knowledge and skills acquired at NBS to the Nation's industries, universities and other government agencies. Of over 100 graduate students and research associates supervised by NBS staff during the past 8 years, 20% are now in industry, 20% in government agencies, and the remainder largely in universities.

For NBS and University researchers alike, perhaps the greatest attraction of JILA is the large concentration of scientific talent in atomic and molecular physics and closely related areas. Neither institution, with its broad responsibility to measurement in one case and to education in the other, could justify such a large number of senior scientists in a single area. For example, the Chemistry Department at the University of Colorado has 18 full professors to cover 5 fields of chemistry, of which chemical physics is a subset of one area. Yet in JILA alone, between the University and NBS, there are four senior scientists in chemical physicists and seven in the closely related areas of atomic and molecular physics. Including graduate students and postdoctoral research associates, these groups comprise some 100 researchers. To my knowledge, this is the largest group of atomic and molecular physicists in the country. Together they are able to collaborate, exchange ideas and attract visiting scientists in a way that would be impossible for two much smaller groups operating separately.

Any scientific group of high vitality and creativity must work in an atmosphere of free-flowing ideas and people. Besides the graduate students and postdoctoral research associates, the Visiting Fellows Program is probably the single most important factor in JILA in maintaining this atmosphere of change and excitement. The Program provides partial funding for some ten internationally distinguished scientists a year to spend up to twelve months at JILA collaborating with resident scientists. Since its inception twenty-four years ago, the Program has become internationally renowned. More than 220 senior scientists from 29 foreign countries as well as the U.S. have participated. The number of applicants exceeds the number of positions typically by a factor of four; in accordance with the Memorandum of Understanding, applicants are chosen according to scholarly achievement, demonstrated interest in the scientific and technical objectives of JILA, and the recommendations of their peers. Funding for the Program is one of the basic responsibilities of NBS as set out in the Memorandum of Understanding and must surely be one of the most cost-effective efforts in the Bureau. Since most of the Visiting Fellows are able to contribute outside financial support in the form of travel fellowships or sabbatical stipends, NBS acquires some of the top talent available in the world's institutions at an average cost of less than one third that of a senior NBS employee. Over twenty percent of the Visiting Fellows have subsequently visited JILA and collaborated with JILA scientists at their own expense.

I now want to turn to a few examples of the NBS work done at JILA, to give you an idea of the range and importance of the contributions the Bureau is making through this institute.

In the relatively new field of chemical physics, researchers at JILA have developed a laser-initiated technique to help understand how combustion really works. The technique uses very short pulses of ultraviolet laser radiation to start specific combustion reactions in a flowing gas mixture. The complete chemical evolution of the laser-ignited reaction is monitored by observing the infrared radiation emitted by the molecules in the combustion process. This work could provide valuable information for improving combustion technology and making engines more fuel efficient.

Another chemical physicist in JILA succeeded in measuring the relative abundance of the radicals composed of silicon and hydrogen present in electrical discharges in silane. Such discharges are used in producing solar cells of amorphous silicon, which could be valuable sources of solar-derived energy if the processes involved in the deposition of the silicon compounds were better understood.

While at JILA as a Visiting Fellow this year, one of the world's top laser spectroscopists from Helsinki collaborated with an NBS scientist on his program of high precision laser measurement. Together they developed a two-mode dye laser scheme, which they then used to cool and stop a beam of neutral sodium atoms. In addition to its broad implication for future frequency standards, this experiment will lead to sensitive tests of postulates of quantum electrodynamics and general relativity.

Applying metrology to molecular physics, JILA scientists have developed experimental techniques for measuring rates of electron excitation of weakly radiating states of molecules. The results of these experiments have been used to improve the recommended electron collision cross sections for gases such as nitrogen, oxygen and neon. These data have wide application in a number of areas including space science and defense. For example, they are currently being used to predict the maximum electromagnetic power densities that can be transmitted from satellite power stations. They are also used to predict propagation characteristics of charged particle beam weapon systems, and to predict the rates of ozone generated by electrical discharges for water purification. As a compliment to these experimental techniques, JILA scientists have developed methods for theoretical modeling that yield information on the performance of high-power, high-pressure electrical discharge devices in molecular gases. These results aid in the development of switches for high power pulsed electrical systems such as are used by the Department of Energy for fusion research.

In the application of metrology to geophysics, JILA scientists are pursuing two quite different approaches for measuring the acceleration of the Earth's gravity. The first is a new portable instrument designed to measure *absolute* gravity to an accuracy of 6 parts per billion, sufficient sensitivity to detect vertical motions as small as 2 cm. The instrument was recently one of two from the United States to take part in an international comparison of gravity measurements in Paris. Such measurements could provide a tool for detecting crustal movements and mass motions below the Earth's surface, which may be associated with the build-up of stress before earthquakes. In the second method, *relative* gravimeters and tiltmeters have been designed to measure extremely small *changes* in the value or direction of the acceleration of gravity. These relative instruments are often used to measure the tidal distortion of the solid Earth. The amplitude of these daily changes is equivalent to a change in the distance from the surface to the center of the Earth of about 30 cm. JILA scientists can measure these changes to 1 part in a thousand; short term fluctuations, such as those that are produced by seismic disturbances, can be detected with considerably greater sensitivity. The amplitudes and phases of these tidal distortions are being used to study the elastic properties of the Earth and the composition of sub-surface material.

In another major project, JILA scientists are exploring the practicality of a space experiment to detect gravitational waves from sources such as colliding black holes and binary stars. The experiment involves the use of laser heterodyne techniques to measure variations in the million-kilometer separation of three masses in Earth-like orbits around the Sun. In an effort to demonstrate the needed laser stability, the researchers have recently achieved an improvement of two orders of magnitude in laser locking capability.

Working in the closely related areas of atomic physics and astrophysics, JILA scientists have initiated a major international collaboration that may result in a much more accurate method of determining the distance scale of the Universe. Our current determinations of the distances to stars and galaxies are based on a theoretical relationship between the absolute magnitudes of certain type of stars and the periods of the variations in their apparent brightness. However, recent evidence suggests that the theory for these pulsating stars is not in accord either with observation or with the theory of stellar evolution. The problem has now been traced to the approximations used in computing opacities at the moderate temperatures and densities of the envelopes of these stars. In collaboration with colleagues in England and Northern Ireland, JILA scientists are therefore undertaking an entirely new approach to these calculations, which will result not only in much more accurate opacity tables, but also in greatly improved values of the relevant atomic data, and ultimately in a new cosmic distance scale.

Here I have given you only a taste of the wide variety of the research carried out at JILA. In still other projects, JILA scientists have demonstrated an ingenious new approach for measuring highly accurate photodissociation quantum yields, have made the first quantitative study of the role of laser phase fluctuations in non-linear absorption processes, have made the first measurements of the magnetic fields of stars cooler than the Sun, have observed for the first time the radiative association of ions and non-polar molecules, have obtained the first high resolution infrared spectrum of a weakly bound Van der Waals molecule, have characterized a new type of Rydberg-like state of molecules, and have used the methods of helioseismology to detect large-scale flows below the solar surface associated with the giant cells of convection; the list could go on and on.

Finally, I would like to summarize the reasons why I believe JILA is an outstanding example of the kind of University/Government cooperative effort that the Administration has been so strongly encouraging. First and foremost, it is a collaboration in which both institutions participate as equal partners, each supporting its own employees, each accomplishing more than it could without the other. An NBS Division of only 22 employees (14 scientists and 8 support staff) influences and participates in the research of an institute of some 200 people including 166 scientists. No where else in either the Bureau or the University could there be such concentration of scientists in closely related areas of research. The sharing of ideas and facilities in such a community allows each scientist to exploit his talent to the fullest; the continuous flow of graduate students, postdoctoral research associates and Visiting Fellows ensures continued vigor and long-term stability of the Institute. JILA's productivity and international reputation in atomic and molecular physics speak for themselves.

Dr. Neal F. Lane

Neal Lane was born in Oklahoma City, Oklahoma in 1938. He received his BS in 1960, MS in 1962, and PhD in 1964, from the University of Oklahoma. He then spent a year in the Applied Mathematics Department at Queen's University, Belfast, No. Ireland, as an NSF Postdoctoral Fellow and year at the Joint Institute for Laboratory Astrophysics in Boulder, Colorado, as a Visiting Fellow. He joined the Physics Department at Rice University as an Assistant Professor in 1966, and was promoted to Associate Professor in 1969, and to Professor of Physics (and Space Physics and Astronomy) in 1972. Lane received an Alfred P. Sloan Fellowship in 1967 and spent six months at the Department of Theoretical Physics, Oxford University, in 1971. In 1975, he was again a Visiting Fellow at the Joint Institute for Laboratory Astrophysics. He served as Chairman of the Physics Department at Rice University from 1977 to 1982, except for one year (1979-80) in which he served as Director of the Physics Division at the NSF. Since 1984 he has been Chancellor of the University of Colorado at Colorado Springs. He has authored or co-authored more than 50 papers and one book. During this time at Rice he has won several teaching awards and sponsored ten PhD students. He has served as a consultant at the Los Alamos and Lawrence Livermore Laboratories and for the National Science Foundation. Currently, he chairs the NSF advisory committee on Advanced Scientific Computing.

Lane has worked mainly in theoretical atomic and molecular physics with an emphasis on collision phenomena involving electrons, atoms and molecules. Research activities at the interface with other subfields include excited states of atoms in liquid helium, interactions of ions and excited atoms with metal surfaces, electron scattering in dense plasmas, and properties of hydrogen in metals.

Mr. WALGREN. Thank you very much for that testimony, Dr. Lane, and maybe we can just briefly explore a point with you and not hold you further.

The thing that is sort of troublesome is that it almost seems like this particular laboratory happened by chance. As I gather, there aren't other examples in the Bureau of the same kind of institute; am I wrong in that?

Dr. LANE. I'm not aware that there's another example precisely like JILA. There are other examples of memoranda of understanding with universities in cooperative activities.

This is the only such institute that I'm aware of that maintains the same sort of balance, that maintains a fairly close balance between the university activity and the Bureau and is of this size and stature.

Mr. WALGREN. Well, I guess something must have come along in the early sixties that captured the attention of the Bureau with respect to astrophysics. But the problem is that systematically, as I see it now, there is nothing that really can give us confidence that similar opportunities would capture their attention in 1985 or 1987. I know of no other proposals, anyway, to initiate new institutes in various areas. To the degree that you feel the Institute has provided some scientific strength where it was lacking because of the fact that we don't have a national science policy, it makes you want to wish that the Bureau had been directed to pursue similar efforts in other areas.

I guess the question is can we recognize the value of this deeply enough to direct that similar institutes or similar efforts be pursued or are we going to just have that be a chance thing that happens every now and then, depending on whether the management is feeling inhibitions or not feeling inhibitions at the time.

Dr. LANE. Mr. Walgren, I think it is true that there was a special set of circumstances. At the time JILA was formed it was clear that we had very poor knowledge of some basic atomic and molecular parameters that were going to be important in understanding, for example, the atmospheric and astrophysical events and other phenomena having to do with space—the near space of our Earth, and the space further away. It was a time of initiative in space anyway, and it seemed appropriate for these organizations to come together. It was also the magic of individuals who were interested in doing this at the time.

I think that's the right way. I feel that what we have here is a model of something that has worked and has been good, good for the university, good for the Bureau, and very, very good for the international scientific community in these particular disciplines that I referred to.

I would, however, expect that other examples will come forward and that they'll come forward in somewhat the same way, that the individual scientists in the Bureau or in the university, or together, would see a special opportunity for a centralization, for a focus on an area of science or engineering technology where both institutions have much to gain, where it fits the mission of the Bureau, is appropriate to the faculty and student involvement of the university, and important to the Nation. I think there probably are some other areas like that, I believe that the correct approach to that is for the scientists themselves to come forward and push for the establishment of such organizations.

It is good to know that it can work, and we have an example before us. I think there is the opportunity to try it again in other areas in the future.

Mr. Walgren. Mr. Boehlert.

Mr. Boehlert. Just one quick question, Dr. Lane.

Near the end of your statement you said you would like to see the Bureau become less dependent on external sources of funding, and the trend seems to be in the other direction. Is this an area of particular concern to you and why?

Dr. Lane. I don't want to speak to the Bureau as a whole because I just don't feel I have the experience to know, in all of the divisions across the Bureau, what the situation is. The Quantum Physics Division, however, is the one that participates in JILA, and in that case my experience is that, for example, equipment money is in very short supply on the Bureau side; and through the years it has been necessary for the JILA scientists to reach out further and further to the other agencies to bring in the necessary support to upgrade the equipment, to buy the new equipment. It is expensive and it is certainly not a criticism of the Bureau that they were unable to provide that support. This is another mechanism of doing it.

It has worked, in that that's a fine facility. It is well equipped. But it takes a good deal of time on the part of the investigators to go to a number of different agencies for that support. That necessarily distracts—that necessarily is distracting away from the time availability to do the basic research.

On the positive side, the availability of that support is good. The fact that there is a plurality of support available to the scientists is good. There would be no opportunity were that not the case. So it is not a terrible situation by any means—I do not want to suggest that it is—but half is a large fraction; and increasingly we see, I think, that the moneys available for basic research have been shifting gradually away from what we in the universities think of as basic research. There has been a tendency to want to see more direct applications out of that money. That worries me. That's a general worry. And to the extent that it will affect JILA's operation, then I'm directly concerned about this Institute.

Mr. Boehlert. It's a concern shared by this committee. Thank you.

Mr. Walgren. Mr. Brown.

Mr. Brown. Could you give us a rough idea of what the budget for JILA is and how it's distributed between the Bureau and——

Dr. Lane. Well, Mr. Brown, I think the total budget of JILA is about $5 million. Somebody could correct me if I'm wrong.

Mr. Brown. I just want a rough idea.

Dr. Lane. I think that's roughly it, and about half of it comes through the Bureau. So the total JILA budget is about $5 million and about half of that is the Quantum Physics Division. And about $500,000 of that is the Visiting Fellows Program.

Mr. Brown. Is it just a coincidence that you're located in the same community with NCAR?

Dr. LANE. I don't now the history, whether there is a direct connection. There is not a strong interaction with NCAR right now. NCAR, of course, has its relationship with the National Science Foundation. There are scientific exchanges and many of the scientists at JILA use the NCAR computer facility. We anticipate, with the new Bureau computer facility, as the lines are connected up—and they're not yet—that that will have a major impact on the computing capability of JILA.

If there are interactions with NCAR, I don't know that there's anything formal, or that there was historically anything formal.

Mr. BROWN. Well, I consider, as you have described it, that this is a most important and interesting institutional arrangement which benefits all the parties, as you have indicated. I had a question as to whether the arrangement, the institutional arrangements, are necessarily optimum from the standpoint of the agency. I suspect the reasons probably are set forth in the report of the Space Science board which resulted in the formation of it. There was a need for much better information about the measurement and understanding of the kind of planetary solar and stellar atmospheres that you're speaking of. That's a rather new field at the time because we were just getting into the Space Program. But it could equally have been done in cooperation with the National Science Foundation, or even with NASA, I would think, in view of the importance of the basic research and its importance to the space program.

But I'm delighted that the NBS has demonstrated this kind of innovative activity and I hope we can see more of it in the future.

Dr. LANE. Thank you.

If I might add, the area that is particularly high priority at JILA, and has been for some years, or recently, has been the area of laser physics, the development of laser technology. And JILA is just an outstanding research center in this field. I mean, it has one of the most distinguished laser experts in the world and it has involved both the university side and the Bureau side, but clearly it is extremely important to precision measurement and new technologies.

Mr. BROWN. Excuse me. Are you getting any feelers from the Department of Defense and the SDI Program for help on their Laser Program?

Dr. LANE. Well, the Department of Defense has been very open with its feelers. I mean, its feelers are out there. It is very interested in having the expertise of the finest laboratories in the Nation, so they have not hidden their desires to involve university scientists very actively in SDI research. Yes; I would say they are very interested.

Mr. BROWN. Well, they are particularly interested in measuring lasers right at this particular point in time.

Dr. LANE. Lasers are among the devices that they feel will be very important in the initiative.

Mr. BROWN. I have no further questions, Mr. Chairman.

Mr. WALGREN. Thank you, Mr. Brown.

Well, thank you very much, Dr. Lane. We understand that you have your obligations you should meet, and we appreciate the time you have given to us.

Dr. LANE. Thank you, Mr. Walgren.

Mr. WALGREN. Now, the question is whether or not we can fit Dr. Toll in here before we all have to go over there and vote.

Dr. TOLL. I understand you have to leave for a vote. I'll be glad to wait until after the vote, if you wish.

Mr. WALGREN. We do have 5 minutes, if that's helpful. But maybe we ought to wait until we come back.

Dr. TOLL. Whatever you say.

Mr. BOEHLERT. We're getting into a real bind now because we're engaged in frivolous activity on the floor, and we're going to be gone at least 15 minutes, and then we've got Dr. Toll and two further witnesses.

Dr. TOLL. Do you wish me to start, and then——

Mr. WALGREN. Would you mind starting? Let's do that.

Let's shoot for 5 minutes and we'll at least use the time efficiently because we have some other good witnesses, and I apologize to them for the delay.

Dr. TOLL. Mr. Chairman, I will try to be brief. You have my written testimony, so I will not repeat it.

I am John Toll, president and professor of physics of the University of Maryland. I have begun my testimony by giving you a quote from a national leader that I thought might interest you, in which he said national leadership should use the acceleration of scientific and technical progress as the main direction of economic strategy, as the main lever for the intensification of the national economy and for raising its efficiency, and hence for the solution of all other problems. I don't know if you recognize that testimony, by Mikhail Gorbachev in his famous speech of June 11, in which he stressed that the Soviet Union is now devoting, or will devote, 5 percent of its national income for the development of science. It has clearly become his national top priority.

Throughout the world there is a similar tendency in other nations, as leaders are recognizing that progress depends primarily upon the priority given to science and technology.

We are fortunate as a nation that we've had a lead technologically over other nations, but that lead is eroding. You can see it in every day in many ways. And I think it's clear that a basic requirement in our society, if we want to be competitive economically, and if we want to have a strong national defense, is that we must maintain the strength of our scientific and technological base.

I think the role of the National Bureau of Standards in this key prime national priority is clear, because the Bureau is the central laboratory that provides the standards on which all science rests, and as our technology becomes more complex, the standards are needed with increasing exactness, and also increase in complexity. We need standards in fields which we haven't had before.

NBS is also the major Federal laboratory with a direct responsibility of working closely with industry. To carry out all of these functions, it has to have a broad, scientific base. As you were discussing earlier, it has to be deeply involved in basic research in a broad variety of fields from the past, principally the physical sciences and engineering.

The excellence of the research at NBS is mentioned in the testimony. In my own discipline, I believe the most important experiment that has been done in the last 40 years was the one done by Dr. Ambler, who was here earlier, and his colleagues, Wa, Hayward, Hobson, Hobbes, and Hudson. It was the famous experiment that showed the fundamental screwiness of the basic interactions of nature. I could go into it more if you wish.

My only point in mentioning it is to stress that it was the most important experiment in physics. It opened up the whole field of research now being pursued in laboratories around the world. It could only have been done in an institution like the National Bureau of Standards, with the diversity of talents and the high quality scientists that were available there.

Mr. WALGREN. Let me ask you at that point to suspend.

Dr. TOLL. OK.

Mr. WALGREN. With that hanging in the air, we will all be back.

Mr. BOEHLERT. We're now going to deal with the fundamental screwiness of the House. [Laughter.]

[Whereupon, the subcommittee was in recess.]

Mr. WALGREN. Well, OK, folks. Let's pick up where we left off. Dr. Toll, you were in mid-flight.

Dr. TOLL. Yes, Mr. Chairman, I was in the middle of my testimony, and I will try to simplify it. My testimony was organized first to emphasize the very key role that the National Bureau of Standards plays, the fact that its role will be more important in the future, that it must have to carry out its function a strong, broad program of basic research. And I was very interested in your comments about whether or not the Organic Act should be changed in that respect. Clearly, it must be recognized, either implicitly or directly that basic research is an important part of the mission of the National Bureau of Standards.

NBS now must expand into new fields like biotechnology. NBS must keep the expertise it has and maintain that expertise at the forefront, but NBS also must go into new areas as well, which NBS has not been involved in before, but areas in which industry now requires that standards be established in order to make progress.

In my testimony, I refer to the longstanding collaboration between the National Bureau of Standards and my own university. I myself have been involved since I joined the university 33 years ago, but long before that there existed cooperation between the Bureau and the University of Maryland. It has been summarized in a memorandum of agreement that provides for the exchange of scientists and cooperative research in many areas. We have also provided graduate courses at the National Bureau of Standards for many years, and over 50 scientists have received advance degrees through that degree program.

The partnership is one which involves cooperation in many different areas, and I won't try to list them all, although I do have information for your staff if they want more information on it.

I thought I would mention a few areas which I think have particular significance. There was some mention here earlier of the Center for Fire Research at the National Bureau of Standards. That has been very important to us as a university. The University of Maryland has the best program in the nation in fire protection engineering. I don't think it's a coincidence that we are located next to the National Bureau of Standards. We have had a close collaboration with the Center for Fire Research. It has been very important for research programs. For example we have a contract relationship that looks at some of the heat transfer problems in jets. In addition, the collaboration has led to the education of many students. So fire research is just one example of fruitfull collaboration of the University and NBS.

The University of Maryland has extensive collaboration with other parts of NBS, such as the National Measurement Laboratory. We work closely with the National Engineering Laboratory in engineering fields. We work with the computer people on robotics and in other areas.

But I think to save you time I will move now to discussion of my recommendations, because you asked me to give comments of what I would suggest for the future of the National Bureau of Standards.

First, it is important to reiterate the key role that the National Bureau of Standards plays as a unique Federal laboratory closely working with industry in establishing standards on which all science depends. Such standards cannot be developed other than by a laboratory with a very broad scientific base, one that must keep up with the changing times. The greatly increasing complexity of this role in national standards means that the National Bureau of Standards will require in the future greatly increased resources if it is to carry out that function and keep up with the rapidly expanding and exacting demands of industry.

Second, NBS in the past has been able to carry out its role only by getting a substantial amount of its funding by contracts with other Federal agenices. This has meant, I think, less stability in the core program of NBS than is necessary. NBS cannot make the kind of long-range development that it should. So I think it's important that efforts be made to increase the proportion of the NBS budget which is not dependent on funding through other agencies.

Now, I'm not suggesting that Congress thereby put a limitation on external grants because that would only make matters worse. The Department of Commerce should be urged to fund a greater proportion of the budget; at the same time the total budget should increase.

Third, the excellence of NBS depends, above all, on the quality of its staff. It's very important that the positions at the National Bureau of Standards should compete in attractiveness with posts for scientists and engineers at the best industrial and university laboratories. Dr. Ambler mentioned today that there are some fields in which that competition is more difficult than others, but in all fields there is difficulty in attracting the very best scientists because the NBS positions are, no longer fully competitive with the best positions. This is an essential factor in which NBS needs help. It may be easier for me to say that than it is for Dr. Ambler.

Fourth, it is important that NBS continue to allow scientists to use its unique facilities, such as the synchrotron and the reactor, which will be increasingly important with the future cold neutron facility. In allowing others to use the facilities, NBS has been limited because NBS has felt that it had authorization only to operate these facilities as directly needed by the needs of the National Bureau of Standards. If other scientists could fit their requirements into those needs, then they could use the facilities. But it would be a very cost-effective expenditure if you could just add a small amount to the budget of the National Bureau of Standards to permit it explicitly to fund the operations of these key facilities when they're needed for outside users.

For example, when some of our scientists go to work at the Brookhaven National Laboratory, or the Fermi National Laboratory, those laboratories know that a key part of their mission is to operate facilities to provide running time, and to provide supporting technical staff, for the outside scientific user. I think it's important if the same kind of authority could be interpreted as being within the mission of the National Bureau of Standards. The additional funds that are involved are not usually great, but they are very important.

In the past we have been able to get such collaboration. For example, on the synchrotron we, through a grant from the National Science Foundation, an additional beam line is being provided, and also equipment for a high quality spectrometer. This joint effort involves the University of Maryland and the Naval Research Lab, with support from the National Science Foundation to work at NBS. And it works. But it's very difficult to arrange that kind of complex cooperation for smaller experiments. It is important, to agree that NBS could have in its budget the funding for the running time and for the support staff for a wide variety of outside users. These users would utilize specialized facilities when justified and without interfering with other functions at NBS.

Further, in planning future facilities, the National Bureau of Standards should determine not only what is needed for its base requirements but should also make some allowance for the needs of other users. Often such external groups could utilize the facility for only a small additional expense, if NBS could provide the additional beam lines, experimental areas and support staff. That's just a sensible way to get the most out of an investment that we're making as a nation for an expensive facility.

Fifth, a somewhat related suggestion is that, in addition to the facilities that NBS builds for its own needs, there are possibilities of major cooperative projects which can be partly used by NBS and partly used by others. In the future we're going to have to share facilities in research more than we have in the past, just because the cost of research installations are increasing. And the National Bureau of Standards would be a logical location for some major facilities that would be cooperative among a group of users, of which NBS would only be one.

I think Congress should encourage the National Bureau of Standards to enter into such consortial arrangements. We have consortia now, for example, for major facilities like accelerators and so on. The National Bureau of Standards would be a logical location for one of the future accelerators that will be needed by our Nation. If you want to study anything with great exactness, you have to get down to very short distances, and, if you want to get down to very short distances, you are required to have high energy. So as part of NBS functions, but also to meet other national needs, NBS should offer a logical place for accelerators that raise particles to very high energy. NBS has space on its location for certain kinds of accelerators so that work can be done by a variety of users. I think NBS would be a good location.

One reason I urge that NBS enter such consortial arrangements is that they would help in attracting and retaining top-flight scientists at NBS. Other Federal laboratories have entered into such national projects for example, the meson factory that is located at Los Alamos. One of the principal arguments for putting that accelerator at Los Alamos, even though it's used for many other purposes than the purpose of that laboratory, is because it helped Los Alamos to attract and to retain top-flight scientists. So picking those kinds of facilities for which NBS has a major use but would not be the sole user, or even perhaps always the principal user, would be a justification for locating facilities jointly at the NBS.

Sixth, the Joint Institute of Laboratory Astrophysics has been discussed by Chancellor Neal as a fine example of an excellent collaborative relationship between a university and NBS. I think it's the single best example. I believe the National Bureau of Standards should be encouraged to develop similar collaborative arrangements with other universities.

You're asking the question, was JILA just an historical accident, and I think Chancellor Lane was right. No, it wasn't entirely an accident. There were clear needs for the kind of work that JILA provides. There are also key people at NBS who have a real interest in JILA, and also at the University of Colorado. But the model has worked; it has worked well; and there are other fields in which I think this model is appropriate.

A clear example in my own mind is the field of biotechnology. NBS has superb scientists for much of the work needed in this field, but it does not have the biological expertise that you need as well. Therefore, it is a clear example of where collaborative arrangements could, I think, work well.

The National Bureau of Standards has also had a very effective postdoctoral fellowship program that's operated through the National Academy of Sciences and National Research Council. Henry Barschall, of the University of Wisconsin, chaired a committee that made a recent examination of that program. The committee verified that it is an excellent fellowship program and that it has been very effective. The committee suggested, and I agree, that it should be expanded considerably beyond the present level of 48 postdoctoral fellowships.

My last recommendation is a rather specific one. It deals with the patent laws. Under present patent law (P.L. 96–517), universities can share patent rights with small businesses. It's been a useful law that has helped collaborative arrangements. The impact of this law will grow as universities become more accustomed to utilizing it.

It would be desirable to extend the provisions of that patent law to include Federal laboratories. For the same reason that we want to encourage collaboration between small businesses and universities, we also want to encourage collaboration between Federal laboratories and business and universities. I believe that, indeed, the extension to include Federal laboratories would be desirable. This legislation is now before the Congress and I just want to state my support for it. I think it would help not only NBS but other major national laboratories as well.

[The prepared statement of Dr. Toll follows:]

Testimony
of
John S. Toll
President, University of Maryland
before the
Subcommittee on Science Research and Technology
of the
Committee on Science and Technology
U. S. House of Representatives
October 2, 1985

Chairman Walgren and Members of the Subcommittee:

My name is John Toll. I am President and Professor of Physics of the University of Maryland. It is a great honor to be invited to testify as part of your hearings to consider the future role and mission of the National Bureau of Standards.

This summer an important speech stated that national leadership should use "the acceleration of scientific and technical progress as the main direction of economic strategy, as the main lever for the intensification of the national economy and for raising its efficiency, and hence for the solution of all other problems."

Have you recognized those remarks? The national leader who so clearly set the top national priority on science and technology was Mikhail Gorbachev, whose speech on June 11 made clear that 5% of the national income of the Soviet Union is being set aside for the development of science!

Throughout the world increasing numbers of national leaders are recognizing that future economic progress and national defense will depend primarily upon the priority given to science and technology.

The United States of America has been fortunate in the past to have had a technological lead, but now that lead is eroding. The basic needs of our society and the international competitiveness of our economy require that we join with other nations in renewed attention to the strength of our scientific base. Otherwise we will be left behind.

In this national priority, the role of the National Bureau of Standards will become increasingly important in the future.

The National Bureau of Standards serves as the central laboratory for establishing standards which will be needed with ever increasing precision and complexity as the demands of an advancing scientific and technological society become ever more exacting. Indeed, all of science and industry requires this foundation. NBS is also the major federal laboratory with the direct responsibility of working closely with industry. To carry out these functions, NBS has had to be the major federal laboratory conducting basic research in a broad spectrum of the physical sciences.

The excellence of the scientific work at NBS has been amply demonstrated again and again by the important discoveries that Bureau scientists have made. In my own discipline the single most important experiment during the past 40 years years was the famous experiment at the National Bureau of Standards by Wu, Ambler, Hayward, and collaborators, which discovered the violation of parity in weak interactions. This experiment suddenly showed that the fundamental laws of nature were far more complicated than had been realized previously. The discovery opened up a whole new vision of the subtlety of nature and led to a series of important discoveries on the symmetries of elementary particles and their interactions that dominate today much of our frontier research. This experiment also demonstrated the importance of scientific breadth at the National Bureau of Standards, for it drew on expertise in many different disciplines, from low temperatures to atomic physics to nuclear physics, from fundamental theory to highly refined instrumentation.

But, if the National Bureau of Standards has shown a diversity of talent and a broad base for its work in the past, the demands in the future will even be greater. Emerging disciplines are now opening new vistas in science. For example, the field of biotechnology offers promise of many new products and processes based on the transfer of genes from one species to another. The new genetic engineering industry will require standards that will depend upon refined techniques from the life sciences as well as the physical sciences, calling on new levels of expertise in disciplines that have not been heavily represented in the National Bureau of Standards in the past, as well as on the Bureau's current excellence.

NBS has continued to improve over the years, but it has not kept pace with the needs of our society. Indeed, no single laboratory can expect alone to meet this national need. A key part of the strategy must involve collaboration with researchers elsewhere, especially those in universities where so much of our nation's basic research is conducted.

University collaborations have been a part of the tradition of the National Bureau of Standards for many decades. Perhaps the best example of university collaboration has been the Joint Institute of Laboratory Astrophysics, but I will say no more about JILA, since it will be dealt with in detail by the next speaker.

My own University is an example of the way in which NBS and universities have interacted to mutual advantage. When I first came to the University of Maryland in the early 1950's, there had already been many years of cooperation between NBS and the University of Maryland. Soon after my arrival, my colleagues and I regularly attended joint seminars with the National Bureau of Standards, participated in joint research projects, and made use of special NBS facilities. This cooperation has been so broad that it led to a "Memorandum of Understanding" that facilitates full cooperation and the exchange of personnel between the University and the NBS. Furthermore, my University provided courses at the Bureau of Standards and opportunity for workers to earn graduate degrees, so that over fifty scientists received advanced degrees from the University of Maryland involving work at the National Bureau of Standards.

Under the broad memorandum of understanding between NBS and the University of Maryland, scientists are working in joint research in so many areas that I could not even list them all in this hearing. Let me just give some examples. I will be glad to give further details on any of these projects that your staff may request:

For example, University of Maryland faculty and graduate students are involved with the Synchrotron Radiation Research Program at the National Measurement Laboratory of NBS. A beam line is being developed and operated under a collaborated agreement between the University and the Naval Research Laboratory, with support from National Science Foundation. A High Resolution Spectrometer is being developed that will be the equal of any equipment in the world.

Many scientists work with the nuclear reactor at NBS. This facility will become much more important with the development of the cold neutron beam: there will then be opportunities for precise low energy neutron experiments not possible anywhere else in the world at this time.

Many of our faculty and graduate students are also working with the National Engineering Laboratory, including research on artificial intelligence and applications to manufacturing. We are very much interested in the whole field of robotics and industrial automation, and work closely under contract with the National Bureau of Standards in this field.

One particularly interesting example of collaborative work involves Fire Safety Research. The Center for Fire Research at the National Bureau of Standards has been an important factor in the development at the University of Maryland of the best academic program in Fire Protection Engineering in the nation. Important research on the transient heat transfer has been conducted under this collaborative program with NBS.

The Center for Applied Mathematics now involves close interaction with six of our professors and their students. These research topics vary from practical problems of resource allocation in energy management and problems in robot vision to advanced theoretical explorations of approximation theory and computational linear algebra, and stochastic modeling of time dependent phenomena.

Recently, the University of Maryland, with the close cooperation of the National Bureau of Standards, Montgomery County, and local industry, establisned a Center for Advanced Research in Biotechnology (CARB). The first facility will be built by Montgomery County at Shady Grove, giving close "line of sight" communication to NBS. In CARB we hope to develop new types of collaboration between industry, universities, and the laboratory. We will be inviting other universities to join in a national consortium to work with the Center for Advanced Research in Biotechnology so that all of us can share our expertise.

Because the time is short, I would like to concentrate now on your request for my recommendations of what can be done in the future to enhance the National Bureau of Standards' role. I would like to suggest the following:

1. First, it is important to reiterate the key role that the National Bureau of Standards plays as the unique federal laboratory working closely with industry to establish the standards on which all science depends. Such standards cannot be developed by other than a laboratory with a broad scientific base working closely with the nation's full scientific community and responsive to the needs of both universities and industries. The greatly increasing complexity of this role requires that there be greatly increased resources for the National Bureau of Standards in the years ahead.

2. NBS has been able to carry out its role in the past only by becoming increasingly dependent on contracts with other branches of the federal government. This has meant that the core program of NBS lacks the stability needed for long range development. I believe that it is important that more of the support of NBS should be made a part of its regular budget so that it is not so heavily dependent on the funding of other federal agencies.

3. The effectiveness of NBS depends above all on the excellence of its staff. Every effort should be made to make positions for scientists at the National Bureau of Standards compete in attractiveness with the posts at the best industrial and university laboratories.

4. Although NBS has been cooperative in making its unique facilities, such as its synchrotron and reactor, available for use by university scientist, there has not been funding for the operation of these facilities other than as justified directly by the needs of NBS. It would be a very cost-effective expenditure to add funds and staff to the NBS budget so as to permit these facilities to be operated when needed by university and industrial users. Further, the NBS mission should be interpreted to authorize explicitly this support for other scientists. For example, when universities go to work at the Fermi National Laboratory or the Brookhaven National Laboratory, it is recognized that these laboratories have a fundamental mission of providing the staff support and running time on their facilities needed by the visiting scientists; the National Bureau of Standards should similarly have such authority, with additional funds to meet the costs of this cooperative effort. In the past, such collaboration has often depended on getting specific support from another federal agency. However, it would be much more efficient if most of the staffing support for outside users would be funded from the NBS budget. Further, in planning its future facilities, NBS should not only determine what is needed for its own uses but also should make an allowance for the needs of other users and should install whatever additional beam lines, experimental areas, etc., are needed for this purpose.

5. In addition to helping others to use facilities planned and built for NBS's own needs, there are possibilities of major cooperative projects. In the future there must be much increased sharing of equipment as the cost of major research installations grows. The National Bureau of Standards would be a logical location for many of these cooperative endeavors. Congress should encourage NBS to consider the development of accelerators and other joint facilities which can be utilized on a national or regional basis. For example, I believe that the National Bureau of Standards would be a logical location for one of the next generation of nuclear accelerators. Congress should encourage NBS to enter into such cooperative projects with groups of universities whenever this is consistent with the mission of the National Bureau of Standards.

6. The Joint Institute of Laboratory Astrophysics has shown what can be achieved by a truly collaborative arrangement between the National Bureau of Standards and a university. I believe NBS should be encouraged to develop similar collaborative arrangements with other universities.

7. NBS has had an effective post-doctoral fellowship program operated through the National Academy of Sciences/ National Research Council. A recent review by an important national committee headed by Professor Henry Barschall of the University of Wisconsin has noted the

excellence of this post-doctoral program and has suggested that it could be expanded considerably above the present level of 48 fellowships.

8. The patent laws now permit the sharing of patent rights by universities and small businesses; this amendment was an important step in assisting collaborative research. I believe that these laws should now be extended to include federal laboratories like the National Bureau of Standards. This would make it much easier for NBS scientists to participate in joint projects. It could also provide incentives for collaborative work which in turn could provide some revenues to support additional work at NBS, and at other important national laboratories.

Mr. WALGREN. Thank you very much, Dr. Toll. We appreciate that testimony.

Mr. Boehlert.

Mr. BOEHLERT. No questions, Mr. Chairman.

Mr. WALGREN. Mr. Brown.

Mr. BROWN. Dr. Toll, I'm sorry I missed most of your prepared testimony. But I note you have mentioned your involvement with the fire safety program and the Center for Fire Research, and we have been raising the subject of whether there were alternative ways of handling that program in the Bureau in view of the fact that it's controversial with OMB—not with the Congress—but OMB seems out to get it in one way or another. We suggested the possibility that it might be a candidate to be established as an engineering research center at some suitable campus with funding for, say, a 5-year period from the Federal Government to get it started.

Could you comment as to whether that might be a reasonable way to solve a sticky political problem?

Dr. TOLL. I think it is possible that the Center for Fire Research could be a candidate for a joint operation on a contractual basis, but I question if the private support would be there at the end of the 5-year period for the kind of work, particularly the kind of grant program that is now conducted by the Center for Fire Research. I don't see where the support would come from. If it came from another Federal agency, the work could still be done, but then there is no saving on the Federal budget. If it is to come from industry, it's hard for me to see how industry would support the kind of broadly based research that is now done, unless a wide consortium, were created of all those interested in maintaining low fire insurance rates. The benefit that the Nation gets from that research is great, but it is hard to see how you can coalesce a group of companies or associations which would provide the stable support after the 5-year program.

Mr. BROWN. That's the most difficult part of the problem. I agree with you on that. But the pattern that we've set with some of these startup facilities—and we've done this for computer centers and large scale computing centers and engineering research centers—is to select a proposal which included some initiative at bringing in private funding, so that there would be some assurance of continuity. But that takes the hard work.

But, on the other hand, OMB takes the view that if we cut out the program, industry might pick it up, if they were forced to, and we keep saying, well, demonstrate to us that they would pick it up and we might be willing to consider some phasing of the program from Government to industry or university sponsorship.

Dr. TOLL. I think it would be unfortunate if the broad and basic nature of both that center and its grant program were not maintained; if these could be maintained by other sponsorship, then that is an approach that one could consider.

We do have at the University of Maryland some research centers that are supported by industry. The Asphalt Research Institute, for example, is located on our College Park campus and receives all of its support from the asphalt industry. But it has been very hard, even for that institute, to maintain a research program that keeps up with the times. Inflation has eaten away substantially in the effectiveness of the research program.

Mr. Brown. Other universities have done the same thing. MIT has done this and a number of others that could be mentioned. But obviously this is the tough part of the job, getting a consortium of industries that would see sufficient importance to the research that they would be willing to agree to support it on a long-term basis. It's not impossible. It's just that it takes a little hard work and perseverence and ingenuity and maybe some other things I haven't thought about.

Dr. Toll. The University of Maryland is part of one of those consortia nationally that was funded by NSF. We work with the San Diego-centered group.

Mr. Brown. Yes.

Dr. Toll. I think such collaboration is somewhat easier for computers than it would be for fire research.

Mr. Brown. Correct. The problem with fire research, and the reason we set it up in the Bureau, is that you have a highly decentralized, fragmented clientele for the results of that research. That makes it difficult.

On the other hand, the Department of Commerce went to considerable effort to get a private consortium to take over the operation of the Landsat system, which I would prefer to give to the University of Maryland or someplace like that.

I have no further questions, Mr. Chairman.

Mr. Walgren. Thank you.

Mr. Ritter.

Mr. Ritter. No questions.

Mr. Walgren. Well, on behalf of the committee, we want to express our appreciation to you.

Dr. Toll. Thank you, Mr. Chairman.

Mr. Walgren. The next panel, Dr. Jim Leonard, vice president of technology, Bethlehem Steel Corp., and Edward Nemeroff, the president of Datron Instruments, who I understand is accompanied by Mr. Jerry Hayes, who is the president of Hayes Technology.

I want to express our appreciation for your patience. I often wonder what it is that drives people to wait for us. I hope that the opportunity to contribute to the national discussion is of some meaning to you, as it is to us. We appreciate your patience through the afternoon.

I would like to recognize my colleague, Mr. Ritter, to introduce Dr. Leonard, who is a special constituent of his, but one who we consider as sort of a special constituent of this committee and a special constituent of an industry that both Don and I are very interested in.

So, Mr. Ritter.

Mr. Ritter. Thank you, Mr. Chairman. It's with pleasure that I welcome my constituent, whom I consider my colleague, and certainly no novice to this committee, a chief technical person within AISI this year, working with the Industrial Research Institute. But today I think he's got some very unique remarks for this committee, and I think it reflects his experience with Government, with the university as professor and chairman of an engineering department, as a small business entrepreneur, having formed and built and then sold his own company, as a manager, a technical manager and general manager for major manufacturing outfits in this country, and today as vice president for technology of Bethlehem Steel, a tremendous responsibility in a difficult time. So it's with great pleasure that I welcome my constituent, Jim Leonard.

I yield back, Mr. Chairman.

Mr. BROWN [presiding]. You may proceed, Dr. Leonard.

STATEMENTS OF DR. JAMES H. LEONARD, VICE PRESIDENT, TECHNOLOGY, BETHLEHEM STEEL CORP.; AND EDWARD NEMEROFF, PRESIDENT, DATRON INSTRUMENTS; ACCOMPANIED BY JERRY L. HAYES, CONSULTANT, CHIEF SCIENTIST OF METROLOGY

Dr. LEONARD. Thank you, Mr. Chairman, and thank you, Congressman Ritter, for those fine words. I'll try to live up to them.

And, Mr. Chairman, with your concurrence, I would like to read a portion of my written statement. I think you will see from the nature of it why I would prefer to do that.

Mr. BROWN. Dr. Leonard, the full text of your statement will appear in the record and you may read whatever part of it you wish.

Dr. LEONARD. All right. Thank you.

And I would like to say first that the invitation to testify before this committee on the future role and mission of the National Bureau of Standards is an appropriate opportunity I think to talk first about the major problem facing American manufacturing industries today, and then I want to state a key role I perceive that the Federal Government and especially the National Bureau of Standards should play in addressing that problem and in regaining our international competitive superiority in the long run.

Now, the National Bureau of Standards is the only Federal laboratory with the explicit goal of serving U.S. industry and science. The U.S. Department of Commerce has made industrial competitiveness a cornerstone of its programs recently. Each year over 500 university, industry, and Government people work side-by-side with NBS researchers in areas of materials science, engineering, measurements, and computer sciences. The working relationship between the steel industry and the Bureau, for instance, started nearly 80 years ago with pioneering work which has evolved into the Reference Materials Program and substantial joint activities in sensor development.

The Bureau will also be a key participant in the so-called Keyworth initiative proposed by the President's Science Adviser in 1984 for joint efforts by the steel industry, the national laboratories and the NBS, funded in part by industry and the Government, and this is intended to result in the development of so-called leapfrog technology to improve our steel industry's international competitiveness. Funding for that initiative has been recommended by this committee and approved by the House Appropriations' Interior Subcommittee.

The unique feature of the collaborative efforts which would be funded under this initiative is the side-by-side development and commercialization of new technologies meeting the so-called demand pull of the marketplace as opposed to the development of technology determined by what might be called policy push which may not be sensitive to market and commercial forces. The question is whether relatively small industry and Government collaborations can improve American industrial competitiveness enough and whether that now provided by the Bureau, and what might be provided by Keyworth-type initiatives, is sufficient in view of the magnitude of the crisis American manufacturing industry is certainly facing.

The future of U.S. manufacturing is threatened by overseas competitors that are able to take advantage of our relatively free market situation. Because of lower wages, Government subsidies, and the high value of our dollar, the United States is losing its share of the world market in such industries as automobiles, steel, shoes, textiles, and machine tools, to name a few.

The initial reaction of these threatened basic industries is to seek help from Washington through limitation on imports, as in the case of the automobile and steel industries, or through protective tariffs as proposed for shoes and textiles. Such limited relief may give these basic industries some needed time to improve productivity through technology modernization, but, in the long run, our basic industries must seek a new comparative advantage in foreign trade. Otherwise, our many workers face a decreasing standard of living as more manufacturing jobs are lost overseas and to be replaced only by lower paying jobs in the service sector. In the long run, U.S. manufacturing must develop and utilize the most advanced technology possible and thus, admittedly, minimize direct labor costs, because developing countries will always have a substantial unit labor cost advantage as well as access to the technology currently available worldwide.

The forefront of advanced manufacturing technology is clearly in complete automation of entire manufacturing processes, and that is where American industry will have to be in order to have any chance to be world competitive. Although direct employment in manufacturing industries as we know them today will inevitably decrease as a result, the factory automation industry, newly created, will generate more and better jobs than those lost in the manufacturing plants being automated. In the longer run, increased use of automation will generate a new wave of innovation and high capital turnover that will in turn make our Nation more competitive internationally and that, in turn, means greater wealth and higher levels of employment on the national scale.

Now, the National Bureau of Standards has recognized the importance of automated manufacturing by establishing, in cooperation with the Department of Defense, interestingly, an automated manufacturing research facility [AMRF], which is scheduled to be fully operational next year. This facility focuses on the application of what is known as programmable automation on discreet parts of so-called batch manufacturing and assembly processes using machine tools and robots, all controlled by a computer network. This effort is being funded at the relatively low-level of less than $4 million per year, out of a total Bureau budget of over $200 million. There is no systematic Government research effort that I am aware of which focuses on semicontinuous and continuous types of manufacturing processes as opposed to parts processes. Let me explain just a bit.

There are three basic types of automated manufacturing processes: First, discrete part manufacturing and assembly which emphasizes robots, computer controlled conveyance systems, or material handling systems, and sensors for inspection and placement and assembly of parts.

A second kind is called continuous process, such as for chemicals, where robots are not of prime importance and the need is for better sensors and more integrated control systems.

There is a third type called semicontinuous processes, typified by steelmaking and finishing, where robots are secondary and the need is for improved sensors, automated, rapid material handling facilities—and heavy ones, beyond the capability of robots—and fully integrated factorywide control systems.

Central to automating all three types of processes are sensors and integrated factorywide production control systems. Now, in Japan and elsewhere overseas, long shipping times to their distant overseas markets tend to drive manufacturing toward long duration production runs of standard products. For us in the domestic market, in contrast, our best competitive position is for relatively short production runs of specialized products satisfying a wider range of customer needs that standardized imports cannot provide quickly. This emphasizes rapid changeover of production from one particular product to another in a single production facility while retaining, hopefully, the low unit cost of the longer runs.

Only a fully automated factory can accomplish that fully. But to do this, especially as a retrofit in existing factories, is extremely difficult and has not yet been fully accomplished anywhere. It takes enormous resources beyond the capability of any one operating company, even when utilizing those relatively few computer and process controls companies trying to meet this need for fully integrated manufacturing systems. Some pioneers are GM/EDS, GE and Westinghouse, but none has succeeded completely. The basic reason is the extreme complexity and difficulty in linking together and then integrating overall these facilities with computerized plant order entry, production inventory control, work force mobilization, and other such computerized management and integration of information systems.

What is needed to accomplish this is a close-knit, fully integrated team approach involving manufacturing equipment suppliers, computer and control systems suppliers, compatible data transmission system suppliers, software integration firms, training and personnel development institutions, all combined with very tight project management control with full participation of the company that will operate the entire system. No one organization or group of organizations yet has this full capability. Competing domestic suppliers trying to meet this are driven to different "niche" type products, not toward integration, in order to differentiate themselves from other domestic competitors. Further, much of the hardware and associated control equipment is now coming from overseas suppliers.

This all adds up to a very capital-intensive, organizationally difficult and stressful task ahead for U.S. industry. Unfortunately, much of what is being done so far in the United States to modernize manufacturing facilities actually consists largely of capital outlays going overseas for technology development and systems, as well as for new manufacturing machinery. That is not only sending the leading edge of manufacturing technology overseas, but it is also driving the relatively high skill jobs in supplying such technology systems overseas as well.

For example, who is making and selling as well as using the most robots? Japan. Where are the continuous casters for steelmaking coming from? Japan and Europe, including much of the associated computer control systems and software, by the way. Suppliers overseas are getting a new technology lead at our expense. We are paying for these systems delivered from overseas firms, and those firms learn more each time they put one in for us and then immediately put what they have learned at our expense back into their own plants, and then later they sell that new technology around the world. That's what we're losing out on.

We must retain automation research, development, design and manufacturing leadership at home. This has to be done, in my opinion, in the private sector—for quick response and protection of technology reasons—but no one private company today has this total capability. Neither does any single operating company have the resources to fully automate all its operations, and that includes the largest among us.

The role of Government then, I believe, should be to serve as catalyst for bringing together our total national capability to do this vital job not only through research and technology development but, beyond that, through encouragement of the formation of what I am going to choose to call super companies to take on this enormous task of full implementation of computer integrated manufacturing, or what I will call henceforth CIM. Investment of dollars and people in such super companies should be, I believe, from all parts of our society—Government, universities, the financial community, and private industry, because all will benefit from them. This may turn out, in fact, to be an entirely new form of economic enterprise.

I feel that this CIM, computer integrated manufacturing, should become a national priority. Presently, according to OTA, Government-supported research in programmable automation is around $82 million a year, but only $4 million of this is for the direct nondefense related industry application, that is, the National Bureau of Standards work I noted earlier.

But concentrating our total research efforts is not enough. We have got to find new ways to implement the results of concentrated research as quickly and economically as possible. The super company concept I mentioned could be a way to make that happen. Because the results of such a major endeavor will affect all of the manufacturing industries and the U.S. economy as a whole, I propose that an industry, Government, university, collaborative effort on a major scale is appropriate to develop, commercialize, and utilize automation technology in our basic and essential industries. Nothing short of such a major new approach can lead us to regain preeminence in technology-based international manufacturing competition. This could involve bringing together the talents of the National Bureau of Standards, the National Science Foundation, and the national laboratories of the Department of Energy, to name a few, and aligning their strengths with complementary strengths in our universities and the private sector. For example, many of the nondefense related Department of Energy facilities could be brought together with NBS and others under the guidance perhaps of the Commerce Department as participants in one or more of these super companies that I foresee.

This super company concept could be the best way to combine the technical strengths and resources we have in all sectors of the Nation. A board of directors of a super company might include representatives from Government, industries, organized labor, as well as from various parts of the private sector. Equity participation in such a private corporation could be based on input of technology, loaned personnel and facilities, as well as direct financial investments. The super company would research, develop and design advanced automation equipment, purchase the hardware from existing companies, and then provide systems and services to participating companies and market such systems and services to other private sector operating companies in the free market mode. Net income from this endeavor, if any, of course, would accrue eventually to all equity participants in the super company, including the Government, university, and any labor components electing to participate.

I am not calling here for a massive new Federal program. Rather, what I have in mind involves redirection and focusing of current, nondefense research efforts of Federal Government laboratories, including DOE, NBS, and others within existing budgetary constraints. As an example, the so-called Keyworth initiative proposed for and by the steel industry represents a first, relatively small start toward Government/university/industry cooperative research and technology development. Focusing on one of our major basic industries, it can be a model for other larger scope collaborative efforts of the same type directed at improving industrial competitiveness in several basic industries. What I am proposing then is a very much larger magnitude collaborative effort involving more Government facilities and universities, as well as several industries.

It derives from the relatively small cooperative research efforts NBS is doing today, but it extends to a much larger market-driven collaborative commercial organization to achieve international competitive superiority in manufacturing through massive new technology development. We have made such national priority efforts before, notably in the Manhattan Project and in the space race and others. Now let's do it again through the commercial sector this time in computer-integrated manufacturing.

If this national effort is not mounted, I believe the United States is probably destined to lose the international competitive race and, in my view, eventually become a second-class nation. If, however, we can somehow mobilize all of the enormous technical strengths and resources we already have in our universities, our industries, and our various Government units, to work more closely together on key technology priorities, we can certainly regain our technology leadership and thereby preserve and further increase the standard of living for all Americans. That is an objective worthy of a completely new type of organizational approach, and I believe we can accomplish this with the cooperation of all sectors of society.

Perhaps the super company concept could be partially modeled after Comsat, the Communications Satellite Corp., with a board divided between Government appointees and other participants. It could issue stock as well as receive industry and Government contributions of personnel and facilities in exchange for stock. It could have a research and development branch, as Comsat does, except the laboratories could be derived or taken from those in DOE, in NBS, and elsewhere. It would be responsible for getting the results of its CIM research implemented in participating companies and then in other companies as well on a commercial basis. The ownership of the technology developed could be transferred to the using companies in exchange for royalty payments to the corporation, to the super company, that is. Further work on organizational arrangements is obviously necessary to flesh out this concept, but the basic idea is pretty straightforward, as I see it.

I recommend that this committee start drafting the legislation to facilitate the formation of such super companies, using input from all the sectors I have named. And I believe we don't have much time to waste.

I thank you for your attention.

[The prepared statement of Dr. Leonard follows:]

Statement by
James H. Leonard, Vice President, Technology,
Bethlehem Steel Corporation
Before the House of Representatives
Subcommittee on Science, Research and Technology
October 2, 1985

My name is James H. Leonard, Vice President for Technology, Bethlehem Steel Corporation. I am also Chairman of the American Iron and Steel Institute's Committee on Technology and a member of the Public Communications Committee of the Industrial Research Institute. Today, however, I am appearing not as a representative of these institutions but rather as an individual, because I would like to draw upon my previous diverse experience as well. That experience includes nuclear reactor development for the U.S. Navy, Professor and Chairman of an engineering department at a major university, as an entrepreneur having created, grown and sold my own technology business, and Director of Technology and General Manager of two operating divisions for a heavy machinery manufacturer. The invitation to testify before this Subcommittee on the future role and mission of the National Bureau of Standards is an appropriate opportunity, I believe, to talk first about THE major problem facing the American manufacturing industries today. Then I want to state a key role I perceive that the Federal Government, and especially the National Bureau of Standards, should have in regaining our international competitive superiority in the long run.

The National Bureau of Standards is the only Federal Laboratory with the explicit goal of serving U.S. industry and science. The U.S. Department of Commerce has made industrial competitiveness a cornerstone of its programs. Each year over 500 university, industry and government people work side-by-side with NBS researchers in the areas of materials science, engineering, measurements and computer sciences. The working relationship between the steel industry and the Bureau, for instance, started nearly 80 years ago with pioneering work which has evolved into the Reference Materials Program and substantial joint activities in sensor development. The Bureau will also be a key participant in the so-called Keyworth Initiative proposed by the President's Science Advisor in 1984 for joint efforts by the steel industry, the national laboratories and the Bureau, funded in part by industry and the government, intended to result in the development of "leapfrog technology" to improve our steel industry's international competitiveness. Funding for that Initiative has been recommended by this Subcommittee and approved by the House Appropriations' Interior Subcommittee. The unique feature of the collaborative efforts which would be funded under this Initiative is the side-by-side development and commercialization of new technologies meeting the "demand pull" of the marketplace as opposed to the development of technology determined by "policy push" which may not be sensitive to market and commercial forces. The question is whether the relatively small industry/government collaborations to improve American industrial competitiveness such as that now provided by the Bureau, and what might be provided by Keyworth-type initiatives, is sufficient in view of the magnitude of the crisis American manufacturing industry is facing.

The future of U.S. manufacturing is threatened by overseas competitors that are able to take advantage of our relatively free market situation. Because of lower wages, government subsidies, and the high value of the dollar, the U.S. is losing its share of the world market in such industries as automobiles, steel, shoes, textiles, and machine tools. The initial reaction of these threatened industries is to seek help from Washington through limitation on imports, as in the case of the automobile and steel industries, or through protective tariffs as proposed for shoes and textiles. Such limited relief may give these basic industries some needed time to improve productivity through technology modernization, but, in the long run, our basic industries must seek a new comparative advantage in foreign trade. Otherwise, our workers face a decreasing standard of living as more manufacturing jobs are lost to lower paying jobs in the service sector. In the long run U.S. manufacturing must develop and utilize the most advanced technology possible and thus minimize direct labor costs, because developing countries will always have a substantial unit labor cost advantage as well as access to the technology currently available world-wide.

The forefront of advanced manufacturing technology is clearly in complete automation of entire manufacturing processes, and that is where American industry must be to have any chance of being world-competitive. Although direct employment in manufacturing industries will decrease as a result, the factory automation industry created will generate more and better jobs than those lost in the manufacturing plants being automated. In the longer run, increased use of automation will generate a new wave of innovation and high capital turnover that will in turn make our nation more competitive internationally, and that means greater wealth and higher levels of employment on a national scale.

The National Bureau of Standards has recognized the importance of automated manufacturing by establishing, in cooperation with the Department of Defense, an automated manufacturing research facility (AMRF) scheduled to be fully operational next year. This facility focuses on the application of programmable automation in discreet parts or "batch" manufacturing and assembly processes using machine tools and robots, all controlled by a computer network. This effort is being funded at a relatively low level of less than $4 million a year, out of a total Bureau budget of over $200 million. There is no systematic government research effort that I am aware of which focuses on semi-continuous and continuous types of manufacturing processes. Let me explain just a bit.

There are several types of automated manufacturing processes:

(1) Discreet part manufacturing and assembly with emphasis on robots, computer controlled conveyance (materials handling systems) and sensors for inspection, placement and assembly of parts.

(2) Continuous processes (e.g., chemicals) where robots are not of prime importance and the need is for better sensors and more integrated control systems.

(3) Semi-continuous processes (e.g., steelmaking and finishing) where robots are secondary and the need is for improved sensors, automated, rapid material handling facilities and fully integrated factory control systems.

Central to automating all three types of processes are sensors and integrated factory-wide production control systems. Now in Japan and elsewhere overseas, long shipping times to overseas markets drive manufacturing toward long duration production runs of standardized products. For us, in contrast, our best competitive position in our own home market is for relatively short production runs of specialized products satisfying a wider range of customer needs that standardized imports cannot provide quickly. This emphasizes rapid changeover of production from one particular product to another in a single production facility while retaining the low unit cost of longer runs. Only a fully automated factory can accomplish that. But to do this, especially as a retrofit in existing facilities, is extremely difficult and has not yet been fully accomplished anywhere. It takes enormous resources beyond the capability of any one operating company, even when utilizing those relatively few computer companies trying to meet this need for fully integrated manufacturing systems. Some pioneers are GM/EDS, GE and Westinghouse but none has succeeded completely. The reason is the extreme complexity and difficulty in linking process control computers on individual production steps together and then integrating them overall with computerized plant order entry, production inventory control, workforce mobilization, and other such computerized management and integration systems.

What is needed to accomplish this is a close knit, fully integrated team approach involving manufacturing equipment suppliers, computer and control systems suppliers, compatible data transmission system suppliers, software integration firms, training and personnel development, all combined with very tight project management control with full participation of the company who will operate the entire system. No one organization or group of organizations has this full capability. Competing domestic suppliers are driven toward different "niche" products, not toward integration. Further, much of the hardware and associated control equipment is now coming from overseas suppliers.

This all adds up to a very capital intensive, organizationally difficult and stressful task ahead for U.S. industry. Unfortunately, much of what is being done so far in the U.S. to modernize manufacturing facilities actually consists largely of capital outlays going overseas for technology development and systems, as well as new manufacturing machinery. That is not only sending the leading edge of manufacturing technology overseas but it is also driving the relatively high skill jobs in supplying such technology systems overseas as well. For example, who is making and selling as well as using the most robots? Japan! Where are the continuous casters for steelmaking coming from? Japan or Europe, including much of the associated computer control systems and software, by the way. Suppliers overseas are getting this technology lead at our expense. We are paying for these systems from overseas firms, which learn more each time and immediately put what they learn at our expense back into their own plants. Later they sell it around the world.

We must retain automation research, development, design and manufacturing leadership at home. This has to be done in the private sector - for quick response and protection of technology reasons - but no one private company today has this total capability. Neither does any single operating company have the resources to fully automate all its operations.

The role of our government, then, should be to serve as catalyst for bringing together our total national capability to do this vital job not only through R&D and technology development but also through encouragement of the formation of what I will call "super companies" to take on the enormous task of full implementation of computer integrated manufacturing or CIM. Investment of dollars and people in such "super companies" should be from all parts of our society - government, universities, finance, and private industry. This may turn out to be an entirely new form of economic enterprise.

I feel that CIM should become a "national priority". Presently, according to OTA, government-supported research in programmable automation is around $82 million a year, but only about $4 million of this is for direct non-defense related industry application, i.e., the NBS work noted earlier.

But concentrating our total research efforts is not enough. We have got to find new ways to implement the results of concentrated research as quickly and economically as possible. The "super company" concept I mentioned could be a way to make that happen. Because the results of such a major endeavor will affect all of the manufacturing industries and the U.S. economy as a whole, I propose that an industry/government/university collaborative effort on a major scale is appropriate to develop, commercialize and utilize automation technology in our basic and essential industries. Nothing short of such a major new approach can lead us to regain a preeminence in technology-based international competition. This could involve bringing together the talents of the NBS, the National Science Foundation, and the National Laboratories of the Department of Energy, to name a few, and aligning their strengths with complementary strengths in our universities and the private sector. For example, many of the non-defense related DOE facilities could be brought together with the National Bureau of Standards and others under the guidance of the Commerce Department as participants in one or more of the "super companies" I foresee.

This "super company" concept could be the best way to combine the technical strengths and resources we have in all sectors of the nation. A Board of Directors might include representatives from government, universities, organized labor as well as from various parts of the private sector. Equity participation in this private corporation could be based on input of technology, "loaned" personnel and facilities, as well as direct financial investments. The "super company" would research, develop and design advanced automation equipment, purchase the hardware from existing companies, and then provide systems and services to participating companies and market such systems and services to other private sector operating companies in the free market. Net income, if any, of course, would accrue to all equity participants, including the government, university, and labor components electing to participate.

I am not calling for a massive new federal program, rather what I have in mind involves redirection and focusing of current non-defense research efforts of federal government laboratories including DOE, NBS and others, within existing budgetary constraints. As an example, the so-called Keyworth Initiative proposed for and by the steel industry represents a first, relatively small, start toward government/university/industry research and technology development cooperation. Focusing on one of our major basic industries, it can be a model for other, larger scope collaborative efforts directed at improving industrial competitiveness in several basic industries. What I am proposing today then, is a very much larger magnitude collaborative effort involving more government facilities, and universities as well as several industries.

It derives from the relatively small cooperative research efforts NBS is doing today, but it extends to a much larger market-driven collaborative commercial organization to achieve international competitive superiority in manufacturing through massive new technology development. We have made such national priority efforts before, notably in the Manhattan Project and the space race, now let's do it again through the commercial sector in computer integrated manufacturing.

If this national effort is not mounted, I believe the U.S. is probably destined to lose the international competitive race and, in my view, eventually become a second class nation. If, however, we can somehow mobilize all of the enormous technical strengths and resources we already have in our universities, our industries, and our various government units, to work more closely together on key technology priorities, we can certainly regain our technology leadership and thereby preserve and further increase the standard of living for all Americans. That is an objective worthy of a completely new type of organizational approach, and I believe we can accomplish this with the cooperation of all sectors of society.

Perhaps the "super company" approach should be partially modelled after COMSAT, the Communications Satellite Corporation, with a board of directors divided between government appointees and other participants. It could issue stock, as well as receive industry and government contributions of personnel and facilities in exchange for stock. It could have an R&D branch, as does COMSAT, except the laboratories would be taken from DOE, NBS and others. It would be responsible for getting the results of its CIM research implemented in participating and other companies. The ownership of the technology developed would be transferred to the using companies in exchange for royalty payments to the Corporation. Further work on organizational arrangements is obviously necessary, but the basic idea is relatively straightforward.

I recommend that this committee start drafting the legislation enabling the formation of such "super companies" using input from all of the sectors I have named. We don't have time to waste!

BIOGRAPHICAL DATA

Dr. James H. Leonard
Vice President, Technology
Bethlehem Steel Corporation

A native of Cincinnati, Ohio, Dr. Leonard received a bachelor of science degree from the University of Cincinnati and master of science and doctor of philosophy degrees from the University of Pittsburgh, all in chemical engineering.

After receiving his doctorate in 1960, he held managerial positions with Westinghouse Electric Corporation as a scientist and engineer, where he was responsible for designing the nation's first full scale nuclear powered electric generating station.

In 1965 he was named director of the laboratory of nuclear research at the University of Cincinnati. From 1969 to 1974 he was a professor and head of the university's department of chemical and nuclear engineering and chairman of the faculty advisory committee on research.

In 1974 he established an engineering and science consulting firm and in 1977 was named director of the advanced technology center for Allis-Chalmers Corporation. His most recent position with Allis-Chalmers was general manager of the hydroturbine division.

In 1983, Dr. Leonard was elected vice president, technology, for Bethlehem Steel. Reporting to Dr. Leonard are the research, applied technology, technology transfer and ventures, and environmental and governmental programs units. Bethlehem International Engineering Corporation, a wholly-owned subsidiary of Bethlehem Steel, and Chesapeake Specialty Products, a new business venture, also report to him.

Dr. Leonard has been active with numerous professional associations, including the American Society of Engineering Education, American Nuclear Society, American Institute of Chemical Engineers, and the American Iron and Steel Institute, of which he serves as chairman of the Committee on Technology.

Research projects for which he has received several patents have been sponsored by various federal agencies, including some commissioned by the U.S. Environmental Protection Agency. In addition, he has published many technical papers on nuclear power and reactors and is a recognized authority on energy matters.

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Mr. WALGREN [presiding]. Thank you very much, Dr. Leonard.

I realize that you have a plane to catch, too, and in the interest of time, if I could ask our subsequent witnesses' forebearance, we might just talk a little bit about this and then get on to them.

I don't know whether the committee is up to the charge given us at this point, but I sure do hear the reactions of somebody who has been faced with international competition in a targeted and focused way. The steel industry has faced orchestrated national economic efforts of other nations and we have been picked apart in the process. I would certainly like to explore the concept with you, and I know there's going to be a lot of controversy about antitrust and things like that. But at the same time it certainly should underscore for us the fact that what we do rely on the Bureau of Standards for in many ways has not happened and industries have been lost and jeopardized because of it. They are put in a position that is clearly untenable, and where you can reasonably project the loss of the race at that point. I appreciate your testimony as being a real clarion statement of that prospect.

Well, let me recognize Mr. Ritter and then afterwards Mr. Brown.

Mr. RITTER. Thank you, Mr Chairman. I'll be brief.

Are you catching the——

Dr. LEONARD. Hopefully the 5:59 plane.

Mr. RITTER. The 5:59? Well, it's 5:27, so I think we'd better just do this in a minute or so.

Dr. LEONARD. Don't worry about it. This is more important.

Mr. RITTER. I echo some of the comments of the chairman and realize that this is quite a monumental recommendation, by the way. It has some really neat points to it, though. I think yes, there will be need to somehow get around the antitrust situation, and that's something that's with us in American industry in any event as we develop joint approaches towards technology, as opposed to just only joint approaches towards R&D, because the competition is doing joint approaches towards technology development. We're going to have to have that kind of capability as well.

The idea of focusing around computer-integrated manufacturing is an interesting idea. I mean, it is definitely a targeting, is definitely making at least an isolated industrial policy choice. But if you have any idea about the whole machine industry in this country—not just machine tools, but anything that's a machine outside of a calculating machine—those machines are produced overseas, I mean, almost entirely. And every time I take a tour of a manufacturing facility in my district and they show me their latest and greatest widget maker, it invariably has come from somewhere else. As you say, as you get into the computerization of this, the hardware and the software is going to come from abroad, too, as they catch up in these areas. So our leads there are jeopardized. The idea of Comsat is a model. I think it's kind of interesting.

I think you have given us something very interesting to chew on in this committee, and I frankly think, Mr. Chairman, that the committee is up to chewing on it. And I yield back.

Mr. WALGREN. Mr. Brown.

Mr. BROWN. No questions.

Mr. WALGREN. Thank you, Mr. Brown.

Well, we certainly will chew on it, and knowing you, we'll know where to find you and you'll know where to find us. We would be most interested in trying to pursue these thoughts with you.

Dr. LEONARD. Thank you.

Mr. WALGREN. Thanks for offering them in the context of this hearing. We appreciate it very much.

Dr. LEONARD. Thank you very much for the opportunity. I look forward to working with you.

Mr. WALGREN. OK. Then we'll turn to Mr. Nemeroff.

Mr. NEMEROFF. Good afternoon, Mr. Chairman, and members of the subcommittee. I would like to thank you for inviting me here this afternoon, and I would like to take a moment to introduce my colleague, Jerry Hayes. Mr. Hayes is with Hayes Technology, which is a metrology engineering consulting firm. In addition, Jerry has spent over 25 years in the Department of Defense, in the latest capacity that of the Technical Director of the Naval Metrology Engineering Center in California.

I am here today under the auspices of the National Conference of Standardizing Laboratories. My statement is in support of the views of the U.S. measurement community—the users of calibration services of the National Bureau of Standards. The blunt fact is that the Bureau is not able to provide us with the measurement standards and services that we require.

For the past 20 years or so the industry has seen a steady deterioration in the ability of the National Bureau of Standards to perform its most vital service: providing the measurement references for the Nation's industrial, commercial, and Government sectors. Research and development depend upon measurements; production and quality control depend upon measurements. Our health, safety, and defense depend upon measurements. Without the standardizing role of the NBS, measurements made at different places or at different times may vary. Interchangeability of parts—the keystone to modern production and quality control—would not be possible without a consistent and valid measurement base. It would be impossible to control the disaster in Baltimore, the Baltimore fire, at the beginning of the century, simply because the hose fittings of the different fire departments did not mate with the Baltimore fire hydrants. This disaster was one of the highly visible and publicly understood reasons why the Organic Act creating the National Bureau of Standards became law in 1901.

With the passage of time, with the increasing sophistication of measurements, and with our tendency to take for granted that measurements that are made everywhere are the same, the importance, rather than the absolute necessity, of standardization role of NBS began to take for granted and subsequently began to fade. The NBS began to expand in other areas, areas not related to measurements and standards. Each of these expansions met a need which existed but also resulted in a sublimation of the reason why NBS was originally created.

Today, the National Bureau of Standards is a renowned institution of research and technology. Over the years, it has made significant contributions to the body of scientific knowledge. But it has failed to keep pace with the increasing needs of the community which gave it birth—the measurement sector of our economy. Probably nowhere is it more evident than in the communications and defense sector where the NBS capability in microwave and millimeter wavelength measurements has not kept up with the capabilities of our own industry, let alone the capability of other national standardizing laboratories. This lack is by no means the only one; the deterioration of capability extends to almost all measurement disciplines at the Bureau.

It is therefore important to us, the users of the NBS calibration services, to the NBS, and to the Nation, that these hearings are being held. We believe these hearings will provide a forum for the beginning of an essential review of the conditions at NBS, conditions which we feel are leading toward a crisis in our national measurement system and to the Nation's well-being. As we shall point out, these conditions have their genesis in budgetary matters, in organization, and in loss of common vision as to the role of the NBS in national and international science, technology, commerce, and trade matters. Although our concern is for the primary measurements and standards mission of the Bureau, we recognize the importance of other missions, importance not just to the constituencies of those other missions, but to the measurements as well.

We do not accept the continuation of these conditions since they appear to intercede in the primary mission of the National Bureau of Standards, that being the custodian of the Nation's standards and the disseminator of standards technology to all sectors of our economy. Because we, the Nation, have permitted a continuing weakening of this primary mission of the Bureau, we are now faced with a predictable national crisis, one which will have a profound impact not only on our country's ability to be competitive, but also in its ability to maintain a strong security position. The question is whether we can reverse this trend through improved vision and awareness which will lead to a renowned emphasis on the importance of standards and measurements, or whether we will continue to yield to the more glamorous or politically visible missions of the Bureau and thus permit the eventual dismemberment of the national measurement service.

We believe your hearings are, in fact, evidence that others outside of the measurement community are also as concerned as we are about the future role and missions of the National Bureau of Standards.

The conditions at the NBS have not suddenly occurred; they have slowly evolved over the past two decades. They have been developed in spite of good efforts of many well-intentioned individuals at the Bureau, in the Department of Commerce, elsewhere in various Government agencies, in Congress and in the private sector. What is evidence for this view of the impending crisis? What can be done to stop this trend in the near term and to reverse it over a longer period? There are some questions which I will address today.

From our point of view, the view of the users of the measurement services of the Bureau, the NBS was created to provide consistency and validity to the U.S. national measurement system, to provide for fairness and equity in the marketplace, at home and internationally, and to conduct that research necessary to support those purposes. The Organic Act specifies the NBS as the custodian for the measurement standards of the United States and directs that the NBS provide the means for dissemination of these standards to industry, academia, and other Government users. These standards provide an essential basis for millions of measurements made each day to assure that both simple parts and complex systems meet buyer and seller expectations and are reproducible as well as interchangeable. NBS is the Nation's only source for standards and our only link to measurement systems of other nations providing the fundamental basis for international commerce. It is precisely in these areas that our constituency sees the Bureau as losing their position of eminence the most.

For the past 10 years, an increasing number of individuals within the Government and the private sector have voiced concern about the direction the Bureau has been taking. From a public letter to the Director by Peter Stein of Arizona, to observations made by several visiting committees, to more recent actions by industrial organizations—for example, the National Conference of Standards Laboratories [NCSL], and the Institute of Electrical and Electronic Engineers, the IEEE Committee To Promote National Microwave Standards [PNMS]—concern is mounting about the deterioration position of the NBS relative to this essential mission. This deterioration is most evident in a recent national survey of over 1,400 companies and Government activities conducted by the National Measurement Requirements Committee of the NCSL which identified over 118 major critical problem areas that required either a new or improved measurement service from NBS. NBS' response to the survey indicated that 67 percent of the requirements were being addressed by efforts of NBS; however, the timeframes for the new measurement services were, in most cases, much too lengthy to provide relief for these immediate critical requirements. The remaining 33 percent were either not addressed, or so insufficiently addressed that no long-term support to the Nation could even be expected. Copies of this report have been previously given to the subcommittee.

Another recent study by the IEEE Committee To Promote National Microwave Standards has reported a shortfall in calibration services in 75 areas critical to the microwave defense and communications industry services. A report by the armed services has also indicated a significant shortfall in the NBS' measurement services to meet the defense industry and service needs to develop, produce and sustain our weapons and combat systems that are essential to our Nation's security.

In addition, the Union of Radio Science, URSI, made a comparison of 30 national standardizing laboratories, including that of the U.S.S.R. This study, in the field of electrical, microwave, and electro-optical measurement services, clearly indicates that the NBS has lost its international preeminence in these fields. This loss has become a limiting factor in the Nation's competitive position on the high technology issues.

These shortfalls and the loss of stature are reinforced in two recent articles which appeared in RF Magazine and Microwaves, plus an editorial in the Electronics Test Magazine, all recently. We do request that these articles be made a part of the record.

Mr. **Walgren**. We will take them for submission in the record.

Mr. **Nemeroff**. Thank you, Mr. Chairman.

[The articles follow:]

EDITORIAL

The industry stands up for standards

Controversy is inherent in the process of setting standards. It stems from lengthy discussion of and argumentation over self-serving proposals from the few people involved. It is a bore to almost everyone else, and most people studiously avoid the proceedings. Nevertheless, when the indifferent find they cannot plug their widgets into one size socket, the cries ring out far and wide: "For heaven's sake, why are there no standards?"

By any standard, the microwave community is conservative, tightly knit, and without a penchant for Madison Avenue flash or Washington grandstanding. Perhaps it is the conservative nature of the business; or because of a certain pride—a consciousness of being indispensable—attached to those products that are at the forefront of military defense. Whatever the reason, the industry has grown steadily, without the din of breast-beating so common among computer companies. Consequently, it seems our needs have taken a back seat to those of industries more brash or vociferous. Yet few industries need calibration standards more than ours, an industry that prides itself on its hardware built to incredibly tight tolerances.

There has for a long while been a small group within our community that has fought quietly for new standards in regions of the spectrum where there are presently few—millimeter wavelengths. They have warned of the impending crisis at the National Bureau of Standards, which they believe is already understaffed and underfunded, without a clear sense of direction. Not surprisingly, not many people listened to the warnings, even within the industry.

But now, this group, called the Promote National Microwave Standards Committee, has presented a report that portrays the US as a first-rate nation with a third-class commitment to calibration standards. The report comes at a time when the President's Strategic Defense Initiative is calling for production of more and better hardware, sooner, that will operate at higher frequencies. It is also a time when the Pentagon is fighting off charges that an embarrassing number of programs produce hardware that doesn't work. It is a timely report.

Senior Editor Michael Kachmar has pored over the contents of this document and has spoken with members of the committee and representatives of the NBS. His findings begin on p. 37. They illustrate clearly that while there may well be a lack of direction at NBS, there is also a distinct apathy within the industry that has undoubtedly aided the problem. If it takes a report like this one to stir up some interest, so much the better.

Barry Manz

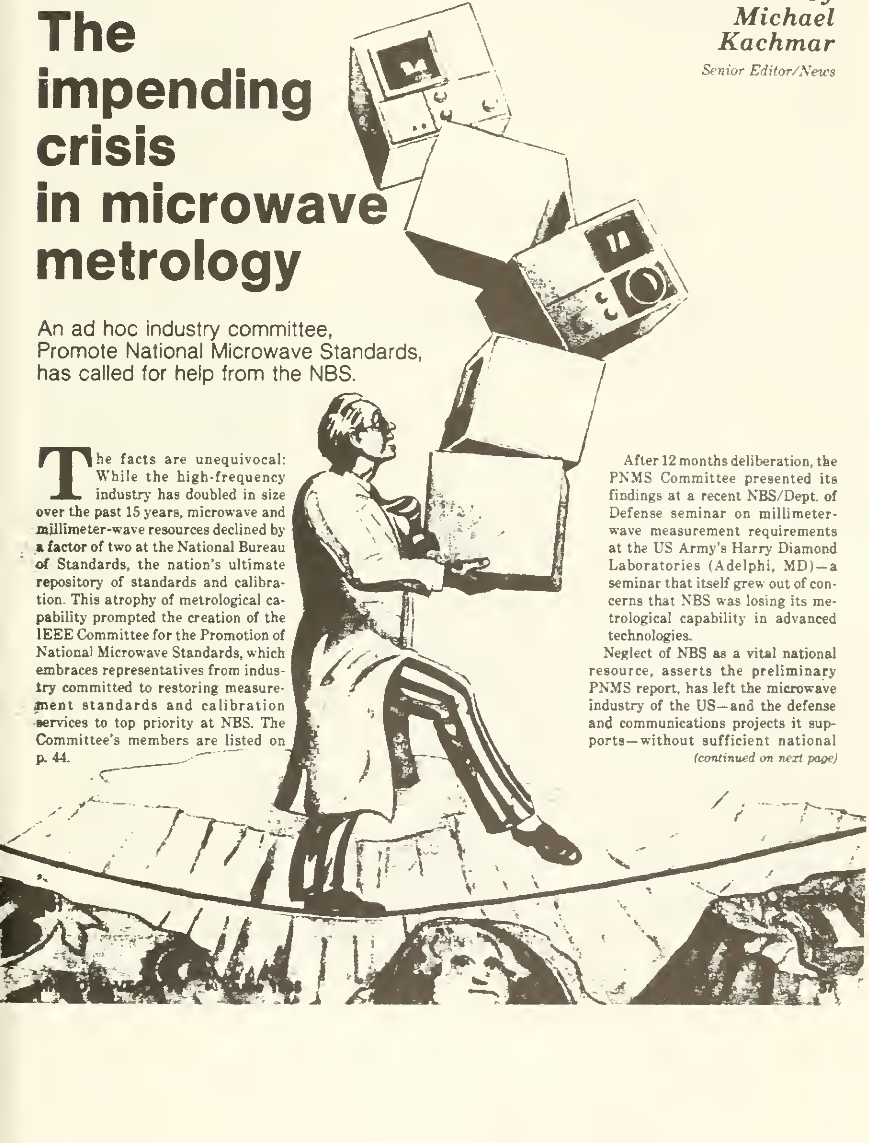
Editor

Part I

The impending crisis in microwave metrology

by
Michael Kachmar
Senior Editor/News

An ad hoc industry committee, Promote National Microwave Standards, has called for help from the NBS.



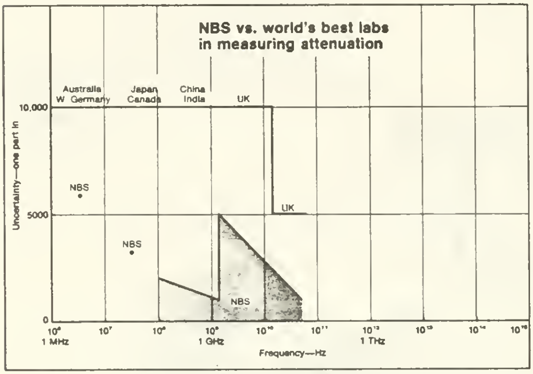
The facts are unequivocal: While the high-frequency industry has doubled in size over the past 15 years, microwave and millimeter-wave resources declined by a factor of two at the National Bureau of Standards, the nation's ultimate repository of standards and calibration. This atrophy of metrological capability prompted the creation of the IEEE Committee for the Promotion of National Microwave Standards, which embraces representatives from industry committed to restoring measurement standards and calibration services to top priority at NBS. The Committee's members are listed on p. 44.

After 12 months deliberation, the PNMS Committee presented its findings at a recent NBS/Dept. of Defense seminar on millimeter-wave measurement requirements at the US Army's Harry Diamond Laboratories (Adelphi, MD)—a seminar that itself grew out of concerns that NBS was losing its metrological capability in advanced technologies.

Neglect of NBS as a vital national resource, asserts the preliminary PNMS report, has left the microwave industry of the US—and the defense and communications projects it supports—without sufficient national

(continued on next page)

Impending metrology crisis *(continued from p. 37)*



1. This chart compares NBS's capability in measuring attenuation *versus that capability in the best labs in the world. The data is based on the "Register of National Standards Laboratories," a report released in August 1984 by the International Union of Radio Science NBS spokesmen warn against taking it at face value, saying that some foreign labs may have submitted their best available accuracy, while the Bureau submitted its readily available accuracy*

measurement references to ensure and maintain the quality of outgoing products and deployed systems. Also, insufficient national measurement service further hampers the microwave industry when competing in foreign markets, where other governments ensure competence in national measurements.

Specifically, the PNMS committee charges the NBS with failing to establish essential services for the SMA connector, the most widely used connector in the world, and for DOD's upcoming MILSTAR system, which will operate at 33 to 50 GHz. Nor are existing services being updated quickly enough, claims the group, which goes on to predict that funding of microwave metrology at NBS for the next five years will fall short of projected requirements by $40 million.

Although the Bureau's measurement capability compares well in the areas of impedance and thermal noise, says PNMS, other national laboratories have better measurement capabilities in the following key areas: low and high power, attenuation, antenna gain, power density, and phase (Figs. 1, 2, and 3). Furthermore, these gaps are increasing to the point that US industry relies increasingly upon foreign laboratories.

Benign neglect

The blame for this impasse lies with Congress, the Office of Management and Budget (OMB), the Dept. of Commerce, and the NBS itself, according to the PNMS Committee. Neglect of microwave calibration services and measurement standards began in the late 1970s on the assumption that the microwave industry was satisfied with the support that grew out of DOD programs a decade earlier (Fig. 4). The result, says PNMS, is a microwave industry with costlier products and longer delivery times, one which now faces the dismantling of an essential national resource amidst a surge of new technologies.

The PNMS Committee is not the first organization to sound such warnings. The National Conference of Standards Laboratories (NCSL) includes 700 metrology and calibration laboratories, more than 600 of which are located in the US. In May 1983, its National Measurement Requirements Committee surveyed members and found immediate needs for nonexistent NBS services. Projected requirements covered 1 MHz to 110 GHz and parameters of power density, field strength, pulse risetime, phase shift, voltage, modulation, phase noise, power, attenuation, impedance, and noise temperature. According to members of the PNMS Committee contacted by *Microwaves & RF*, the results of the NCSL survey are still applicable.

In 1983, enhanced high-power and noise-source measurement capabilities were requested by a dozen NCSL members, with accuracies of 1.5 to 10 percent sought in the high-power area (10 to 200 W CW) from 1 MHz to 2 GHz. The McDonnell Douglas Corp. (St. Louis, MO), for example, reported investing 1260 employee-hours and $6800 for equipment to develop calibration service for bolometer-coupler units when NBS discontinued that service. The company put its additional operating costs at $5300 annually. Rockwell International (Anaheim, CA) seconded the need for high-power measurement service for its L-band telemetry, tracking, and control systems in the 28-satellite Global Positioning System, the first direct application of space technology for the soldier in the field.

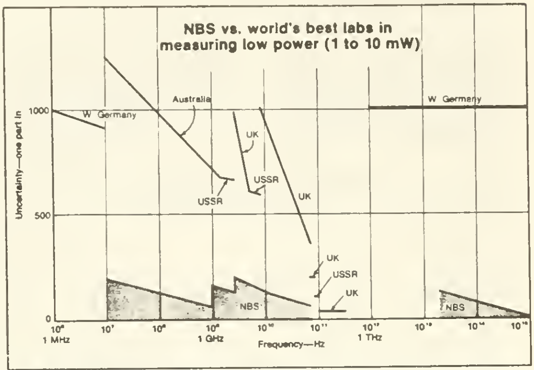
In the traditional area of impedance, five appeals were received for calibration of capacitance between 1 and 10 MHz for values of 10 to 1000 pF and accuracies ranging from 10 PPM to 0.5 percent. Lockheed Missiles & Space Co. (Sunnyvale, CA) noted the growing popularity of impedance meters (in its case, a Hewlett-Packard model HP 4192A) capable of accurately measuring capacitance to 10 MHz. Three additional requests were received for Q standards ranging from 5 to 10,000 over 10 kHz to 70 MHz. For many NCSL members working in the lower RF regions, Q standards are a prime concern.

Every aircraft carrier in the US Navy floats at least one calibration lab. Responding to NCSL's survey, the US Navy's primary measurement unit, the Metrology Engineering Center (Pomona, CA), requested pulse risetime and phase-shift calibration services in support of wideband-sampling oscilloscopes and Collins model 4795-6 signal generators. Similarly, the US Air Force's main metrology facility, at Newark Air Force Station (Newark, OH), requested special modulation calibrations for Hewlett-Packard model HP 8901/11715A analyzers used in support of VHF omnirange (VOR) navigational systems.

TRW (Redondo Beach, CA) noted that the only phase-noise measurement services offered at NBS were time-domain measurements and very limited frequency-domain measurements, performed primarily on special request for 5.0-MHz oscillators by NBS's Time and Frequency Div. in Boulder, CO. Phase-noise measurements, the company maintained, is one of the most critical parameters for many RF, microwave, and millimeter-wave applications. For digital communications systems, TRW said, phase noise is *the* most critical parameter.

Again, McDonnell Douglas complained that it would be forced to develop an expensive alternative means of calibrating commercial instruments—in this case, 1.25-MHz voltage doublers—unless NBS did the job. As a consequence, the company would forego buying another unit. Newark Air Force Station offered the disquieting information that NBS services in the area of RF excess noise-ratio measurements have remained "virtually unchanged" since the Air Force began providing calibrations at the primary laboratory level in 1970. Newark reported gaps in that service below 2 GHz and from 4 to 8 GHz.

In large part, it was the 1983 NCSL survey that raised concerns at DOD over the adequacy of US measurement capability, particularly in light of imminent millimeter-wave systems such as MILSTAR. In December 1983, Edith Martin, then Deputy Under Secretary of Defense for Research and Engineering (Research and Advanced Technology), formed a tri-service planning committee featuring representatives from NBS, DARPA, and the Office of the Secretary of Defense to plan a more orderly approach to identifying millimeter-wave measurement requirements. In an attempt to strengthen communication with DOD, NBS appointed Brian Belanger as liaison, with offices in Gaithersburg, MD, and the Pentagon.



2. NBS capability in measuring low power (1 to 10 mW) *is compared against the capability of the best labs in the world for measuring that parameter. Again, NBS spokesmen question whether the foreign labs are citing their best available accuracy or their readily available accuracy. NBS offers special services, too, remind these spokesmen.*

According to Belanger, NBS people in its Electromagnetic Fields Div. in Boulder, where microwave work takes place, have harbored their own suspicions that too little was being done to stay on top of changing requirements. Belanger points out that many of those requirements occur in classified defense-related projects. He credits George Nicholas, Assistant Director, Electronic Combat Systems, in the Office of the Assistant Secretary of Defense for C^3I, for championing a stronger relationship between DOD and NBS. DOD, remember, performs hundreds of millions of high-frequency measurements each year. Currently, it contributes an annual $28 million to NBS in the form of fees.

"We must avoid situations," says Belanger, "in which someone comes in and plunks a black box on a workbench and asks for calibration, and we discover that it's beyond the state of the art."

In March 1984, representatives from NBS and DOD attended a two-day classified seminar at Harry Diamond Laboratories to discuss deficiencies in the millimeter-wave area. A follow-up seminar, held this year in April, was open to representatives from industry with security clearances. The PNMS Committee requested and received permission to voice its doubts about the ability of NBS in the area of microwave measurements as well. Says Belanger, "I think the PNMS did an excellent job of putting the whole problem in perspective."

NBS needs cash

From all sources, including contracts, fees, and appropriations from Congress ($124 million in Fiscal Year 1985), NBS has a total income of $209 million. Microwave metrology—which includes much of the Bureau's work on antennas—gets about $4.5 million in appropriations and takes in another $835,000 in fees. The PNMS Committee recommends that microwave metrology get an additional increment of $8 million for Fiscal Years 1986 through 1989. Thereafter, it wants NBS to maintain an annual funding base for microwave metrology of $10 million. The Committee believes that $1.5 million per year—nearly one-tenth of the annual $13-million allotment for the next four years—should be spent on new equipment. Thereafter, equip-

(continued on p. 42)

Impending metrology crisis *(continued from p. 39)*

ment purchases can safely drop to about $700,000 a year.

The microwave faction of NBS is overworked and debilitated, the PNMS Committee contends. Although some redirection of funding within NBS may be tempting, it adds, the needs far exceed the small amounts that could be shaken free by redirection.

In the past, Congress has shown little reluctance in assigning NBS new responsibilities. The Brooks Act of 1965, named after its sponsoring Senator from Massachusetts, is perhaps the most notorious example; properly entitled the "Federal Property and Administrative Services Act," it saddled NBS with responsibility for computer technology and awarded no additional funding the first year, and a munificent $560,000 the next.

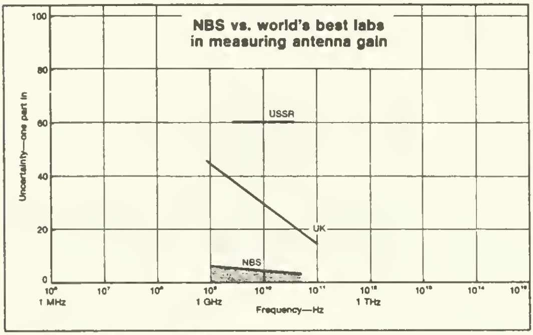
If the NBS fails to submit a supplemental budget request for the additional $8 million for Fiscal Year 1986, the PNMS Committee wants Congress to step in. It is essential, the PNMS preliminary report emphasizes, that the staffs of NBS, the Dept. of Commerce, the OMB, and appropriate Senate and House committees work out ways to get these new funds at once.

Among the many statistics gathered by the PNMS Committee, one cries out: In the next five years, 40 percent of the technical staff at NBS will reach retirement age. This technical staff is considered by many to be the most vital resource America has in the area of microwave and millimeter-wave metrology. One is hard put to find someone in the microwave industry who doesn't praise the competence of NBS technical personnel. One is equally hard put to find someone who thinks NBS will get replacements of equal caliber.

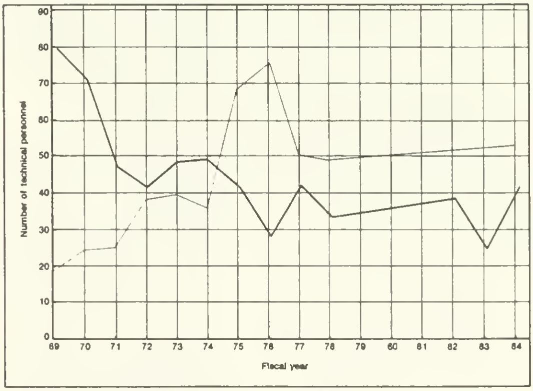
The PNMS Committee suggests that NBS double its present staff of 35 full-time personnel in the microwave area. New development teams are needed, which means recruiting from several levels, including new program managers, senior scientists, engineers, and technicians. State-of-the-art work requires state-of-the-profession engineers. Here a knotty problem arises—NBS workers are on the Civil Service pay scale, and OMB is applying heavy pressure to cut the number of government employees in the GS-11 to GS-15 salary range. Engineers with experience in metrology command salaries ranging from $26,000 to $52,000, which are the parameters of GS-11 and -15. This dilemma leaves NBS planners trying to sell two main advantages of working at NBS: the interesting nature of the work and Boulder's proximity to Rocky Mountain National Park.

The Center for Electronics and Elec-

(continued on p. 44)



3. Here, NBS capability in measuring antenna gain *is compared to that capability in national labs of the UK and USSR. Once again, NBS spokesmen say more research is needed to see what foreign labs really offer.*



4. The PNMS Committee claims that the chart above *indicates a gradual shift in emphasis at NBS away from measurement and calibration and towards basic research and development. The black line indicates full-time NBS technical personnel working in microwave metrology (i.e., parameters of power, attenuation, impedance, noise, voltage, antenna gain, and field strength). The blue line represents personnel involved in more basic R&D in cryoelectronics, electrooptics, interference, hazards, information, superconductors, and remote sensing. Compiling such statistics is difficult because NBS units responsible for microwave work have weathered extensive reorganizations since the Central Radio Propagation Lab was founded in 1946.*

Impending metrology crisis *(continued from p. 42)*

trical Engineering, founded at NBS in 1968, has authority over the microwave metrology effort. Judson French, CEEE's director, says that NBS attracts people who like to do things carefully and thoroughly, which he feels is sometimes impossible in the competitive arena of private industry. In his opinion, a step increase in funding and staff along the lines suggested by the PNMS Committee is highly unlikely. Already, French notes, the microwave metrology group is half again as large as any other group in the CEEE. French believes that NBS can make significant improvements with lower numbers, noting that in the past year the Electromagnetic Fields Div. has added several top-quality technical personnel to its antenna effort.

The chairman of the PNMS Committee is Doug Rytting of Hewlett-Packard (Santa Rosa, CA), program manager for the model HP 8510 network analyzer. Rytting emphasizes that there can be and will be no substitute for NBS as the ultimate repository of national standards, including those for microwaves. "Our goal all along," says Rytting, "has been to help NBS do its job."

With regards to staffing, French points out that the microwave industry can strengthen NBS at once by supporting its Research Associates Program, whereby private industry sponsors personnel that work at NBS facilities. NBS has more than 100 research associates, not one of which, French says, is sponsored by microwave companies.

While maintaining that NBS desperately needs more full-time engineers, the PNMS Committee concedes that competent development teams take two or three years to gel. Meanwhile, it repeats, support of the microwave industry dwindles. The answer may lie in interim government/industry teams that attack immediate problems and buy time for NBS to regroup.

According to the PNMS preliminary report, these teams should have responsibility for the documentation, prototyping, and initial production of all hardware, software, and techniques essential for forging the traceable chains of quality measurement that the high-frequency industry needs. Each group should set design goals that transfer intensive routine calibration services away from NBS, thereby freeing NBS personnel to focus on breadboard and process development—the basic research and development of microwave metrology that critics claim has been neglected. Industry is called upon to convert the breadboard designs into manufacturable items, a business-like approach that would require NBS to advertise its needs in the Commerce Business Daily and develop a qualified producers list.

PNMS envisions these hit teams as training sites for the new NBS employees; as such, they need not be located at NBS facilities. Indeed, many companies and universities already have better facilities than NBS in some technical areas. On the altruistic side, NBS could award academic grants in me-

PNMS measurement priority matrix

Parameter	Coax		Waveguide						
	7.0 mm	3.5 mm	< 18 GHz	18-26 GHz	26-40 GHz	33-50 GHz	50-75 GHz	75-110 GHz	> 110 GHz
Impedence	A	A	B	A	B	A	C	C	D
Power	A	B	B	B	C	A	D	C	D
Thermal noise	B	B	B	B	B	B	D	D	F
Attenuation	B	C	C	D	D	B	C	C	F
High power	C	C	C	E	E	C	G	F	G
Antenna	--	--	E	E	E	C	G	G	H
Power density	--	--	D	D	F	D	H	G	H
Phase noise and switching speed	--	--	D	F	F	D	H	G	H
Phase	D	G	D	G	G	D	H	H	H

A = Highest priority

The PNMS Committee has prepared this preliminary matrix *to help NBS set priorities. PNMS suggests that eight areas (from A to H) with common design goals be addressed from June 1985 to October 1990 in order of importance. The highlighted letters in the matrix represent areas in which NBS provides limited metrological service or no service at all. PNMS also notes that there are no NBS services for SMA connectors. DOD's upcoming MILSTAR program operates from 33 to 50 GHz.*

The Promote National Microwave Standards Committee

Douglas Rytting (Chairman), Hewlett-Packard
Bruno Weinschel (Vice-chairman), Weinschel Engineering
Mario Maury (Secretary/Treasurer), Maury Microwave
Alan Carlson, M/A-COM, Inc. •
Jerry Hayes, Science Applications, Intl.
Frank Koide, Rockwell Intl.
Peter Lacy, Wiltron
Algie Lance, TRW
Robert Powell, Weinschel Engineering
Paul Roberts, Hughes Aircraft Co.
Wendell Seal, TRW
Gunther Sorger, Eaton Corp.
Robert Weber, Lockheed Missiles & Space Co.
Lielsons
Judson French, National Bureau of Standards, for NBS
D.H. Caldwell, US Navy Metrology Engineering Center, for the Calibration Coordination Group

trology, which get work done as well as encourage students to pursue careers in measurement science. By the same token, industry could donate equipment, although the PNMS Committee warns NBS against depending on handouts.

Setting priorities

Too often, say critics of NBS, the priorities of measurement standards have been subordinated to other concerns. These critics believe the time has come for NBS to commit itself to an agenda of clear, immediate goals. According to PNMS, these goals should focus on the installation of new measurement and standards capabilities rather than on the less demanding task of improving existing services. Foremost among these goals is the need for automated system design to accomplish calibration services with fewer, less skilled personnel.

NBS has made advances on this front by introducing its state-of-the-art six-port automatic network analyzer. While some observers have criticized the Bureau for supplying more than one six-port to DOD, French points out that supplying all the six-ports that DOD needs are the terms under which funding was obtained from DOD's Calibration Coordination Group, adding that providing equipment for other federal agencies is as much a part of NBS's mission as anything else. French also questions whether NBS could find private companies willing to build advanced equipment with the severely limited production runs typical of NBS systems.

On one point, however, there is no debate: NBS resources in microwave metrology have remained static while the industry they support is growing by 15 percent a year. Put another way, there are too many problems for NBS to solve at once. According to NBS spokesmen, the PNMS Committee's best work has been done in preparing a matrix of parameters and priorities to help the Bureau set its goals. This "PNMS measurement priority matrix" is shown on p. 44. Each of the eight priority groups (listed alphabetically in importance from A to H) encompasses segments of the high-frequency industry with common design problems. In the PNMS scheme, these capabilities would be established from June 1985 to October 1990.

The PNMS also urges NBS to institute a calibration standards and referral service to assure US industry of support in cases where national capability is lacking. Until NBS prowess can be restored, believes the PNMS, help must be solicited from foreign standards labs. This referrel service would advise US industry of national and international surrogate laboratories capable of filling immediate metrology needs.

What the PNMS Committee has requested is something difficult to measure—renewed dedication and commitment to standards and calibration services on the part of NBS and those responsible for its funding.••

Next month, in the second part of our report on NBS, Microwaves & RF *examines the possibility of getting more funds for microwave metrology and talks with NBS leaders about how it apportions its resources.*

NEWS

The impending crisis in microwave metrology

"Neglect of the National Bureau of Standards has left the US microwave industry without sufficient national measurement service," asserts the preliminary report of the IEEE Committee for the Promotion of National Microwave Standards. The PNMS Committee includes representatives from industry committed to restoring measurement services and calibrations to top priority at NBS. In the June issue of *Microwaves & RF*, we presented the Committee's preliminary findings. This month, we talk with the leadership of NBS about the Bureau's plans for microwave metrology.

by Michael Kachmar
Senior Editor/News

Part II

The NBS sets its sights on

Administrators at the National Bureau of Standards respond to the negative criticism of the microwave metrology effort from the IEEE Committee for the Promotion of National Microwave Standards by thanking the Committee for being comprehensive and systematic.

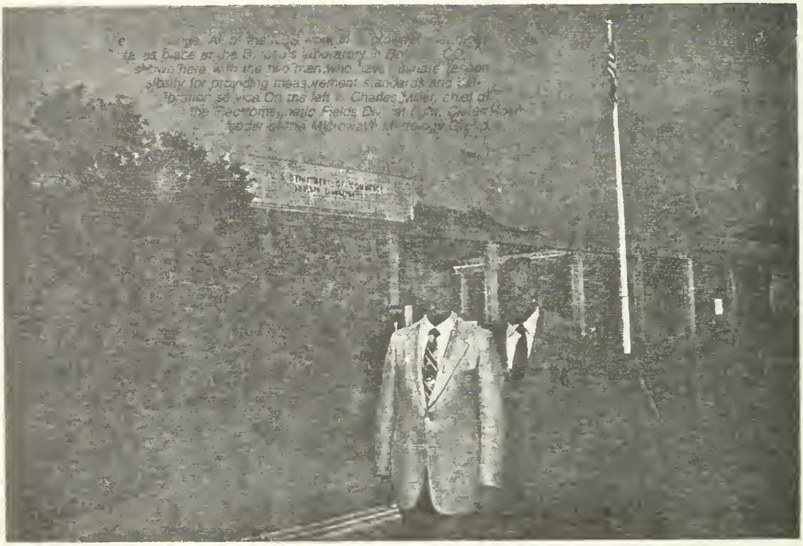
Says NBS director Ernest Ambler, "The PNMS Committee has performed a very valuable service. Most importantly, they've ranked their needs in order of priority. We certainly intend to take their priority matrix very seriously." (The PNMS priority matrix, introduced in the first part of this report, separates the high-frequency industry into eight priority groups—listed alphabetically in importance from A to H—with common design problems.)

Charles Miller is chief of the Electromagnetic Fields Div., Center for Electronics and Electrical Engineering, the NBS unit with responsibility for microwave metrology. In an interview at the NBS facility in Boulder, CO, he concurred with Ambler: "As an independent advocate, the PNMS Committee does nothing but help us. We will address their "A" and "B" priorities first. We have no argument with their priorities—many lie in directions we were already heading."

Most generous with praise for PNMS is Cletus Hoer, leader of the Microwave Metrology Group in the Electromagnetic Fields Div., who points out that the NBS would have had to expend some of its already limited resources in order to do the kind of industry survey the PNMS Committee has provided. "They've done a lot of work," Hoer maintains. "I appreciate what they've done and I hope they continue They're doing us a favor by pointing out areas in which we lag "

The PNMS Committee's preliminary report, presented at an NBS/Dept. of Defense seminar on millimeter-wave measurement requirements held in April at the US Army's Harry Diamond Laboratories (Adelphi, MD), suggests that the NBS capability in microwave metrology has atrophied to the point that the Bureau is inferior to many national laboratories in the following areas: low and high power, attenuation, antenna gain, power density, and phase.

In an interview at NBS headquarters in Gaithersburg, MD, Ernest Ambler noted that the Bureau tends to be very conservative in quoting its capabilities. "I just don't believe that every country in the world does far better standards and calibration work than we do," Ambler states. "Whenever we do round-robins, there's no indication that they do. I'm prepared to believe that there's some particular calibra-



[illegible] nge. All of the [illegible] work in [illegible] is done at the Bureau's laboratory in Boulder, CO, shown here with the two men who have ultimate responsibility for providing measurement standards and calibration service. On the left is Charles Miller, chief of the Electromagnetic Fields Division; at right, Clete Hoer, leader of the Microwave Metrology Group.

better measurement services

tions at some particular laboratories that may be better."

"I'm aware of a few areas where discrepancies exist," admits Chuck Miller, "but some of those are being corrected. We have not added personnel in the areas of attenuation, impedance, or power, and that's where we're suffering at the moment."

That the NBS lags in the area of power measurements is confirmed by other NBS personnel in Boulder. Clete Hoer observes that the NBS quotes levels of certainty for power measurements from its available, cost-effective services. He suspects that other national labs quote the best level of certainty they can achieve by using a calorimeter (Fig. 1). "I doubt they give that level of accuracy to all their customers," Hoer says. "However, the PNMS Committee does have a legitimate concern with regards to power. We haven't been able to work on calorimeter measurements for five years. We don't have the manpower to do all the thorough error analysis that needs to be done in the power area."

"Twenty years ago," explains Miller, "without a doubt, the NBS was the leader in microwave metrology. Now other countries are developing their own standards capability, so they can compete with American industry. There was a time when NBS offered quite a bit of support for the relative size of the microwave industry. When that industry entered a lull, the NBS rightly questioned its level of support. Well, the microwave industry bounced back five years ago, and we got caught behind the eight ball."

The question now becomes how the NBS plans to get out from behind that eight ball. According to Ambler, the Bureau is highly respected by members of the Reagan Administration. Whether that respect can be translated into an increase in funding in these days of budgetary anorexia, of course, is another matter.

The cool million

On April 16, Rep. Don Fuqua (D-FL), chairman of the House Committee on Science and Technology, entered the following into the Congressional Record during debate on bill H.R. 1617, which would authorize future NBS funding. "The Committee urges the NBS to review its list of priorities for new initiatives to meet measurement needs in process and quality control technology in light of the March 1985 position paper of the Committee to Promote National Microwave Standards of the IEEE and other recent industrial statements of calibration needs. Furthermore, the Committee urges NBS, the Dept. of Commerce, and the Office of Management and Budget to give serious consideration to

(continued on p. 37)

Better measurement services *(continued from p 85)*

the merits of a sizable increase in these efforts, taking into consideration the defense and trade implications of this important work."

In its preliminary report, the PNMS Committee had called upon NBS to increase its funding of microwave metrology by the unlikely figure of $8 million annually for Fiscal Years 1986 through 1989. At present, microwave metrology—which includes much of the Bureau's work on antennas—gets about $4.5 million in appropriations and takes in another $835,000 in fees From all sources, including contracts, fees, and appropriations from Congress ($124 million in Fiscal Year 1985, with about the same expected for 1986), NBS has a total income of $209 million.

Ambler confirms what was already assumed when he reports that the Bureau will not ask for a microwave-metrology budget increase of the magnitude proposed by PNMS. The Bureau, however, has requested an additional annual increase of $940,000 for the effort as part of the process and quality control program cited by Fuqua. The request has passed the full House and Senate, and awaits final action by conference committee. According to some NBS spokesmen, the intensity of PNMS activity has already convinced the NBS leadership to request additional funds for 1987 and beyond—a rumor Ambler will neither deny nor confirm.

Even greater funding may be in the cards should Brian Belanger continue his successful lobbying for NBS in the Dept. of Defense. Belanger was assigned as NBS/DOD liaison a year and a half ago to help the NBS get a better handle on upcoming DOD systems that will need calibration support. In the past, the NBS has dealt with DOD's Calibration Coordination Group, an arrangement unsuitable for addressing the needs of future systems, since CCG contracts stipulate that the NBS provide specific hardware, such as six-port automatic network analyzers (Fig. 2).

Many observers date the beginning of microwave metrology's decline at the Bureau back to the mid-1960s when the DOD began solving its metrology problems in other ways. According to hopeful NBS employees, the DOD has plans to contribute $33 million over five years to the NBS for RF work as part of a larger $100-million research and development effort. According to Belanger, if the program gets funding—which is undetermined at the present time—a large portion would certainly land at NBS. Signs are very good, Ambler says, that somehow or other the DOD will come up with funds for the NBS.

1. Calorimeters are used to achieve *the most accurate microwave power measurements. The NBS uses the microcalorimeter shown here to measure the effective efficiency of specific bolometer units (i.e., temperature-sensitive resistors in appropriate transmission-line mounts) used in calorimeters The calibrations from the microcalorimeter are transferred to customers' units by reflectometer or six-port techniques.*

Fees are capped

This world presents some problems that money can't solve, but providing accurate calibration support for advanced RF systems isn't one of them. For a variety of valid reasons, the NBS is restricted to charging fees for its measurement and calibration services that recoup the actual cost of performing the services, plus the cost of calibrating and maintaining active systems. Since its active systems can only be maintained to the point at which they were originally developed, Hoer feels, the fee structure dictates that the NBS fall behind the state of the art.

Since Hoer was involved in the development of the NBS's six-port automatic network analyzer, one way to engage his full attention is to relay industry criticism of the project. "We put several million dollars into our old network analyzer, which we still use for calibrations from 0.1 to 18.0 GHz," Hoer explains. "The system is so complicated that we've never been able to determine its accuracy. When the six-port is finished, we'll have an instrument that can assess its own uncertainty and determine its own random errors. For every measurement it makes, it will print out a realistic estimate of the systematic errors. Now, maybe everyone won't want a six-port, but for a standards lab, it's the way to go."

"Limited resources mean special approaches," Miller observes. "There are some people in the microwave industry who remember when the NBS used a large number of manual systems. I don't think they realize the position we find ourselves in. We're also developing the only automated radiometer in the world, which uses the six-port. It hasn't been criticized because we haven't publicized it as much. We developed the near-field antenna-scanning technique, too, and 10 years later industry decided to use it. I know of one aircraft company that now has nine of them at a cost of $1 million

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Better measurement services *(continued from p. 37)*

each. I expect the same thing to happen with many of our new measurement techniques."

"We hung out our dirty laundry on the six-port as we went along," says Hoer sadly. "We did it to help other researchers."

More candid yet is Ambler's assessment of the six-port issue. "The six-port will give us the capability to do a wide range of calibrations," Ambler argues. "We can't establish a standard for every individual product. There's just too many. Some people in the microwave industry won't build and use the six-port, so they don't see it as any help to them. They need things calibrated, they don't care how it's done."

Both Miller and Hoer believe that the PNMS Committee's call for NBS to increase its use of automated measurement systems represents a change of thinking among members of the microwave industry. Likewise, both feel that the PNMS suggestion that the NBS contract out more of its development work misses the mark.

Says Hoer, "One reason the six-port was not contracted out was because we gained expertise in building it. More importantly, only one third of the money for the six-port came from inside the NBS. If I hadn't gotten money from the CCG to build six-ports for DOD, I would have been forced to let personnel go—which would have put the project even further behind."

"Whenever we need large numbers of an item, we do contract it out," Miller maintains. "In the past, these

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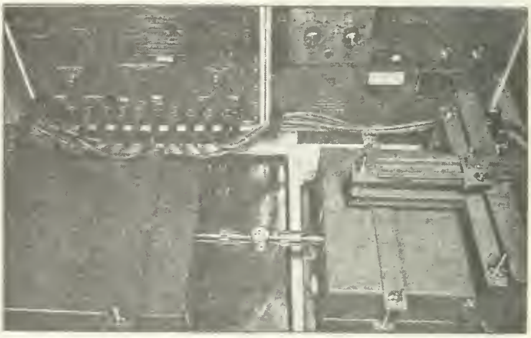

2. NBS personnel believe that the six-port *automatic network analyzer will provide the means to do a wide range of calibrations. Shown here is the NBS six-port setup for 20 to 1000 MHz. The actual six-port consists of the two boxes in the foreground of the photo, the same console and a different six-port will provide measurements from 100 kHz to 30 MHz.*

View from the top

Some critics have accused the National Bureau of Standards of conducting research and development projects at the expense of its measurement and calibration services. During an interview in his office at NBS headquarters in Gaithersburg, MD, the question was put to Director Ernest Ambler.

"I get that criticism from every group that buys services from us," Ambler told *Microwaves & RF*. "If you tell me that the Bureau should only work on current needs, you're not going to have an NBS worth a damn in five or ten years. Optical signaling, for instance, is the wave of the future. You can bet your last dime that the Bureau is going to be called upon to characterize fibers, diodes, laser emitters, and couplers. We're going to have a whole range of new measurement problems. We're going to do that, we're going to take care of the future as well as the present.

Ernest Ambler, director of the NBS

"In my judgment, this notion that NBS works on exotic projects at the expense of bread-and-butter calibration comes from people who think they're involved in the only important discipline in the world. Some people think that NBS should only be doing what they want and that everything else is irrelevant. They think fire research is irrelevant. Well, the Reagan Administration thinks it should be done by the private sector, too, but Congress doesn't think that. Congress appropriates money in our budget for fire research and it becomes law. We have to do it. Some people think that providing interface standards for computers is irrelevant to NBS. Well, that's the biggest problem identified by the computer industry—the things can't talk to each other, and it costs an arm and a leg in software. Still, these people claim that NBS shouldn't be doing that, it should only be doing do what they want." ●●

Better measurement services *(continued from p. 38)*

projects have included special dry calorimeters and power meters. In cases in which we build copies of our systems for other federal agencies, the numbers are so small that we can't interest private companies."

MAPS folds up

In the mid-1970s, Bruno Weinschel, president of Weinschel Engineering (Gaithersburg, MD), 1985 president-elect of the IEEE, and vice chairman of the PNMS Committee, pioneered the concept of the Measurement Assurance Program, or MAP. Put simply, a MAP functions by having an individual standard travel in a circle of users, with one company serving as the "pivot" lab that reports back to NBS.

"You set up a protocol so that an individual shop knows where it stands in relation to the NBS and in relation to everybody else," Ambler says of MAP. "It's a wonderful method of measurement control."

As it turns out, however, it's also an expensive method of measurement control. Like most aspects of the relationship between the NBS and the microwave industry, there are two sides to the demise of the high-frequency MAP program. Although the NBS only seeks to recover its costs in the fees it charges, those costs have risen with inflation over the past decade. According to some users in the microwave community, NBS fees have risen to the point that some companies now consider less accurate alternatives to the services. These users claim that the solution lies in an effective high-frequency MAP program.

"We tried to put together a MAP in the areas of power and attenuation about two years ago," Clete Hoer replies. "We wanted to accredit other laboratories to disseminate our standards. We put together a package and passed it around to a dozen interested companies. The cost of the whole MAP process had to be recovered, but the companies were only willing to pay on-going costs, not developmental costs."

"The NBS runs several successful MAPs," adds Miller, "but they involve sophisticated users willing to maintain their own facilities so that statistical control can be maintained. We found that microwave companies wanted cheaper support without being willing to make the necessary commitment. That commitment mandates that they maintain statistical control in their own facilities—for us to do it at NBS isn't enough."

For all practical purposes, the high-frequency MAP program is dead. The following eulogy was delivered by Hoer: "Maybe MAPs work only for basic standards like mass and temperature. Complex standards such as impedance—which may involve phase or amplitude—vary over an entire measurement plane. Any certified lab would have to be capable of measuring accurately over the whole plane, not merely at a single point."

Who's buying now?

Experts in microwave metrology are difficult to find under the best circumstances, forced to operate under the Civil Service pay scale, the NBS finds problems aplenty. NBS spokesmen admit that the Bureau has had difficulty replacing several established leaders in microwave metrology who were lost to retirement or budget cuts. Thankfully, there now seems to be progress in an effort to exempt the NBS from the consequences of the 1984 Report of the Grace Commission, which found too many middle managers on the federal payroll. Middle managers fall into the GS-11 to GS-15 salary range ($26,000 to $52,000)—the same range that applies to the scientists NBS needs. According to Mat Heyman, a spokesman for the NBS in Gaithersburg, MD, the House has agreed to restore $450,000 in salary money in Fiscal Year 1986 so that the NBS can hire scientists at GS-11 to GS-15. The Senate, however, has yet to concur.

In its preliminary report, the PNMS Committee suggested that joint

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NEWS

Measurement services

(continued from p. 40)

government/industry efforts might alleviate NBS personnel problems. The PNMS Committee is still debating the specifics of many of its proposals, and intends to elaborate on this concept in a later report. Still, several problems seem apparent with this approach.

"While the concept of interactive programs seems good," Miller warns, "at NBS we would worry that people from industry would try to finish things too quickly, that they wouldn't evaluate errors and record the sources of those errors, two crucial requirements for a standards lab. When we hire people, we find that it takes several years for them to demonstrate the caution and care that NBS exercises."

Ernest Ambler asks the microwave industry to consider the kind of cost-sharing arrangements that are gaining favor in many other high-tech areas. Specifically, Ambler notes, the NBS runs a Research Associate Program that has had more than 1000 participants. This program is notable in the microwave area for its lack of support.

But while they are grateful for any help, some employees in the trenches of NBS microwave metrology question the effectiveness of research associates. Most associates stay at the NBS for six months, hardly long enough to make much of a contribution. "After you take time to instruct the person, you wonder how far ahead you get," says one NBS employee at Boulder. "Perhaps if we got someone with experience in a particular area where we're lacking, it could help. Someone from a nearby company that could commute to hold down the sponsor's costs. Someone, say, from a good metrology lab."

Nonetheless, there is indeed one way the microwave industry could immediately improve the quality of NBS measurement standards and calibration services. It could donate equipment. In its preliminary report, the PNMS Committee suggested that the NBS spend $6 million for new equipment for microwave metrology over the next four years. Curiously, PNMS called upon NBS to establish an equipment-donor program. The suggestion seems aimed more at members of the

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Better measurement services *(continued from p. 42)*

microwave industry than at the Bureau, since nothing now stops private companies from donating equipment. Indeed, NBS receives noteworthy donations of equipment in other technical areas.

Overall, $400,000 a year is earmarked for new equipment for the NBS microwave, millimeter-wave, and EMI efforts. To do the job in the MILSTAR frequencies alone, NBS will need hundreds of thousands of dollars of new equipment. To put the problem in perspective, Miller reports that this year the Electromagnetic Fields Div. spent almost $200,000 for one item, an HP-8510 network analyzer.

"Equipment is a real problem for us," Miller admits. "Everyone knows how expensive klystrons are and what narrow bandwidths they have in the millimeter-wave frequencies. We never bought any equipment for the 40-to-50-GHz band because there weren't any applications. If industry is so inclined, we'd accept anything."

A priority matrix of NBS equipment needs would start with power amplifiers, TWTS, and spectrum analyzers. "Those kind of contributions could really help," says Hoer somewhat wistfully.

"Donations notwithstanding, we're grateful for the position the PNMS Committee has taken," Miller emphasized. "Congress likes to hear from industry. The aerospace industry once served as our advocate, but the PNMS Committee could be more effective because it ranges over a broader spectrum, from component manufacturers to system houses."

The members of the PNMS Committee have pledged to keep the standards and calibrations issue in the national spotlight. Meanwhile, the NBS is working on its budget for Fiscal Year 1987. Clearly, both groups have promises to keep if the NBS is going to reestablish the undisputed preeminence it once held in the area of microwave metrology. ●●

Mr. NEMEROFF. It is clear that the actions taken over the decade, and continued through this year are now being felt as severely as predicted by individuals in both our Nation's industry and Government agencies. Unlike many services of the Bureau, providing measurement references for the Nation is not transferrable. The NBS is our sole source and is therefore either a long-term limiting or accelerating factor on national and international issues.

The measurement and standards role of the NBS is critical to all sectors of our economy and to all levels within those sectors—from research, to development, to production, to point of sale and beyond. Science, engineering, manufacturing, commerce and trade, as well as national security, all depend upon measurements, measurements which are consistent and are valid because of the standardization role of the NBS.

The rate at which industry can bring the fruits of research and development to useful, competitive products is highly dependent on valid measurements and standards. The utility of products that are competitively produced from multiple sources also depends upon this measurement and standards base. The significance of measurements on our overall economy was indicated in a recent report to be 3.5 percent of the gross national product, or in 1948, a total of $163 billion. For 20 measurement-intensive sectors, the contribution is even more dramatic. For those sectors, the value added by measurements was 13.5 percent or, in 1984, $80 billion.

With a contribution this large, $80 billion for measurement intensive sectors, and $163 billion overall, it is obvious that any action or inaction which serves to deliberate the basis of the system will have far-reaching consequences. Erosion of capabilities for measurement standards and services at the NBS have such consequences, although they are slow to surface. Some of the consequences of our past unwillingness to fully support the measurement standards mission of the NBS are now only being felt. One area where this has become visible has led to the formation of a special committee of the IEEE previously mentioned. This report indicates that key measurement requirements for the Milstar Program are without measurement standards at NBS. This has forced the DOD and industry to develop costly and time-consuming workarounds. In these and other measurement areas, the effects of actions or inactions of the past are only now being perceived.

We realize that the National Bureau of Standards performs a variety of functions for the Nation beginning with the missions outlined in the Organic Act of 1901, and as amended from time to time, and extending to technical roles directed by Congress over the years. In our view, it would be a mistake to cite these additional roles—that is, the Brooks Act of 1965, Consumer Products Safety Act of 1973, Privacy Act of 1974, Energy Policy and Conservation Act of 1975, and so forth—as the cause of these current problems. Rather, they are contributors to the current situation.

For example, the NBS is perceived by many in Government and the private sector as the only nonspecific, laboratory-oriented, scientific agency of the Federal Government. Thus, when scientific or technical studies or actions are required, the NBS is usually designated as the agency to carry it out, even though the study or action is not a standard one. In many respects, this makes sense. However, to the extent that these added studies or actions are expected to be carried out within the existing budgets or manpower ceilings—a typical situation—all other functions assigned to the Bureau are impacted negatively.

In addition, over the recent past the NBS has made certain organizational changes which we believe have served to defocus the fundamental and primary measurement and standards purpose of the Bureau. The creation of the National Measurement Laboratory and the National Engineering Laboratory have fragmented the measurement and standards thrust to the point where there is no emphasis or market-based strategic planning for measurements or any commonality between the two laboratories on this vital purpose. Organizational defocusing has been highlighted by the current lack of measurement services user panel to review the continuing adequacy of NBS measurement services and the proliferation of roles that I previously referred to. When the Directorate of Measurement Services was eliminated, its high-level panel was also eliminated.

This role as custodian of the Nation's measurement standards and provider of these standards—through calibration services—to the myriad of users is not glamorous, nor does it attract the attention, say, a major fire or building failure does. This role is, and probably rightly so, a transparent one that is taken for granted, as we have come to expect that products perform as advertised. When they don't, we find that quality or some other measurement intensive factors has limited product performance and acceptance.

This transparency, though, implies to many that its priority relative to more visible or more glamorous roles is less. The implication leads to a disinterest of scientists and engineers to enter the field, to a management philosophy that tends to reduce emphasis in this sector and to trade off its important functions for more publically and politically visible ones, and to the administration and Congress to overlook the measurement focus.

We sincerely appreciate the opportunity you have provided us with to suggest our recommendations for the roles and missions of the National Bureau of Standards as it moves into its second century. You have the awesome responsibility of making the vital decisions which will shape the course of history for the NBS, for all of us who depend upon it, and for the Nation's industrial and commercial well-being. We hope our contributions will be helpful in your deliberations.

What should the National Bureau of Standards be doing in the next 15 years, by the year 2000? That depends to some extent on what you see it as now and what role you think the Government should play in these various missions. It is our judgment that the NBS is first the national standardizing laboratory of the United States. This mission requires that NBS scientists carry out research in the fundamental units of measurements, in many derived units, and in related areas. It requires that this research be translated into useful service by development of appropriate standards, publications of data, maintenance and custody of existing U.S. national standards, and the provision of the means to transfer these standards to industry, commerce, academia, and Government. It also requires that the NBS scientists, engineers, and managers involved in this activity participate in various forums aimed at identifying problems, setting priorities, sharing results of research, and so forth.

As a first approach, we believe that a part of the long-term solution is the need to immediately refocus the various competing missions of the Bureau such that its practical objective again becomes that of being the custodian of national standards and providing a means of transferring these standards to industry and commerce. And this means that at the very least all measurements and standards work at the Bureau must answer to one center or laboratory director.

We believe the time has come, perhaps already passed, when a critical review of the performance of the NBS must be undertaken and a course of action defined to correct the conditions which have led to the perception that the NBS has fallen far short of meeting national requirements. Therefore, to help us attain the objective of redirecting the NBS to its principal mission and to continue the momentum provided by these hearings, Congress should support the execution of a special independent commission. This commission should examine all facets of the NBS, emphasizing the measurement standards purpose. The goal of this examination should be to establish a direction for the future of the NBS, including all missions and potential future missions. The composition of this commission should be strong in membership from the measurement user community, those who have the greatest knowledge of these needs. This has not always been evident in the past committees participating in the overviewing NBS activities.

We do not believe that the standarizing mission of the Bureau should be separated from its other important missions. But if that is the only way the standardization role can be returned to its rightful place as the principal reason for the existing of an NBS, then the other missions should be removed from the NBS and placed elsewhere. Another alternative to consider would be to make the Bureau itself a part of a larger department of science or technology wherein the standards mission is preeminent.

We also realize that part of what needs to be done may be politically distasteful. If all of the missions of the Bureau are of equal importance, then they all must be funded to that equal position. We cannot afford to let one basic important mission—measurement and standards—continue to be eroded because it is not glamorous or because it is perceived as the least visible.

Therefore, one element of a solution requires improvement of the resource base, the budget, by a significant amount. Development of this budget should be based on industry and other Government agency assessment of the annual national measurement services program. Management at all levels of the DOC and NBS should be committed to execution of this plan.

Another part of the solution requires an examination of the overall budget process itself which allows—perhaps ensures—that this condition will recur and get worse. Greater attention should also be paid to the use of universities and industrial or other Government laboratories, not only to develop new and improved measurement services, but to also expand the development of our most scarce resource, dedicated and competent metrology personnel. Of course, without an increased budget base and focus on the measurement service area, this attention seems unlikely.

While this suggestion has long-term payoff, immediate results can only be obtained by utilization of existing international standards and measurement services as well as having NBS coordinate and validate measurement assurance programs which have been developed by NBS and others.

We believe that the role of the visiting committee, its membership and selection process—indeed, its purpose—should be reevaluated. The various evaluation panels of the NSF should be similarly reviewed. As in management and organization suggestions and funding proposal, it is necessary that all panels and evaluation committees renew their interest in and focus on measurements and standards.

At this point in the history of the United States, nothing is more important in the area of technology development, manufacturing and international trade, than the need to improve quality—in perception as well as actuality—and the resulting improvement in productivity. Attainment of quality depends absolutely on our ability to measure, to ensure that what is specified or required is achieved. And measurements depend upon the foundation of measurement equipment and standards which have a known relationship to an ultimate reference—in the United States, the standards maintained by the National Bureau of Standards.

Many within the measurement community have believed for some time that there has been a continuing and serious atrophy of NBS' contribution to measurement science and services which would not be felt by this Nation for some time. That time has passed. The situation is serious and, if allowed to continue, will result in a total breakdown in our national measurement system and its essential support to our Nation's economy and security. We believe immediate and major steps must be taken in the areas of mission focus, organization, planning, budgeting, and the use of other national resources to begin the slow process of restoring the keystone to our national and international measurement systems.

Thank you, Mr. Chairman.

[The prepared statement of Mr. Nemeroff follows:]

HEARINGS ON THE FUTURE ROLES AND MISSIONS OF THE NATIONAL BUREAU OF STANDARDS

BEFORE THE

SUB-COMMITTEE OF SCIENCE, RESEARCH AND TECHNOLOGY

U.S. HOUSE OF REPRESENTATIVES

PRESENTED BY:

EDWARD NEMEROFF

PRESIDENT

DATRON INSTRUMENTS

OCTOBER 2, 1985

Good afternoon Mr. Chairman and members of the sub-committee. I am appearing today under the auspices of the National Conference of Standards Laboratories. My statement is in support of the views of the U.S. measurement community - the users of the calibration services of the National Bureau of Standards. The blunt fact is that many of us are unable today to meet the needs of our organizations because the National Bureau of Standards has not been able to provide us with vital measurement standards and services.

The past 20 years or so has seen a steady deterioration in the ability of the National Bureau of Standards to perform its most vital service: providing the measurement references for the nation's industrial, commercial and governmental sectors. Research and development depend upon measurements; production and quality control depend upon measurements; our health, safety and defense all depend upon measurements. Without the standardizing role of the NBS, measurements made at different places or at different times may vary. Interchangeability of parts - the keystone to modern production and quality control - would not be possible without a consistent and valid measurement base. It was impossible to control the disastrous Baltimore fire at the beginning of this century because the hose fittings of the many fire departments involved would not mate with the hydrants of Baltimore. This disaster was one of the highly visible and publically understood reasons why the Organic Act creating the NBS became law in 1901.

With the passage of time, with the increasing sophistication of measurements, and with our tendancy to take for granted that measurements made were everywhere the same, the importance - or rather the absolute necessity - of the standardizing role of the NBS began to be taken for granted and subsequently began to fade. The NBS began to expand in other areas, areas not directly related to measurements and standards. Each of these expansions met a need which existed but each also resulted in a sublimation of the reason the NBS was created.

Today, the NBS is a renowned institution of research and technology; over the years, it has made significant contributions to the body of scientific knowledge. But it has failed to keep pace with the increasing needs of the community which gave it birth - the measurement sector of the economy. Probably no where is this more evident than in the communication and defense sector where the NBS capability in microwave and millimeter wave measurements has not kept up with the capabilities of our own industry, let alone the capability of other national standards laboratories. This lack is by no means the only one; the deterioration of capability extends to almost all measurement disciplines at the Bureau.

It is, therefore, important - to us, the users of the NBS calibration services; to the NBS; and to the nation - that these Hearings are being held. We believe these Hearings will provide a forum for the beginning of an essential review of conditions at the NBS - conditions which we feel are leading inexorably towards a crisis in our National Measurement System and to our nation's well being. As we shall point out, these conditions have their genesis in budgetary matters, in organization, and in a loss of common vision as to the role of the NBS in national and international science, technology, commerce and trade matters. Although our concern is for the primary measurements and standards mission of the Bureau, we recognize the importance of other missions - importance not just to the constituencies of those other missions, but to measurements as well.

We do not accept the continuation of these conditions since they appear to intercede in the primary mission of the National Bureau of Standards, that being the custodian of this nation's standards and the disseminator of standards technology to all sectors of the economy. Because we - the nation - have permitted a continuing weakening of this primary mission of the Bureau, we are now faced with a predictable national crisis, one which will have a profound impact not only on this country's ability to be competitive, but also in its ability to maintain a strong security position. The question is whether we can reverse this trend through improved vision and awareness which will lead to a renewed emphasis on the importance of standards and measurements, or whether we will continue to yield to the more glamorous or politically visible missions of the Bureau and thus permit the eventual dismemberment of the U.S. National Measurement System.

We believe your Hearings are, in fact, evidence that others outside the measurement community are also as concerned as we are about the future role and missions of the NBS.

The conditions at the NBS have not suddenly occurred; they have slowly evolved over the last two decades. They have developed in spite of good efforts of many well-intentioned individuals at the Bureau, in the Department of Commerce, elsewhere in various government agencies, in the Congress and in the private sector. What is the evidence for this view of an impending crisis? What can be done to stop this trend in the near term and to reverse it over a longer period? These are some of the questions which I will address today.

From our point of view - the view of the users of the measurement services of the Bureau - the NBS was created to provide consistency and validity to the U.S. National Measurement System, to provide for fairness and equity in the market place, at home and internationally, and to conduct that research necessary to support those purposes. The Organic Act specifies the NBS as the custodian for the measurement standards of the U.S. and directs that the NBS provide the means for disseminating these standards to industry, academia and other government users. These standards provide an essential basis for millions of measurements made each day to assure that both simple parts and complex systems meet buyer and seller expectations and are reproducible as well as interchangeable. NBS is the nation's only source for standards and our only link to measurement systems of other nations providing the fundamental basis for international commerce. It is precisely in these areas that our constituency sees the Bureau as losing their position of eminence the most.

CURRENT CONDITIONS AT THE NBS - THE PROBLEM

For the last ten years, an increasing number of individuals within government and the private sector have voiced concern about the direction the Bureau has been taking. From a public letter to the Director by Peter Stein of Arizona, to observations made by several Visiting Committees, to more recent actions by industry organizations, i.e., the National Conference of Standards Laboratories (NCSL) and the Institute of Electrical and Electronic Engineers (IEEE) Committee to Promote National Microwave Standards (PNMS), concern is mounting about the deteriorating position of the NBS relative to this essential mission. This deterioration is most evident in a recent national survey of over 1400 companies and government activities conducted by the National Measurement Requirements Committee of the NCSL which identified over 118 major critical problem areas that required either a new or improvement measurement service from NBS. NBS' response to the survey indicated that 67% of the requirements were being addressed by efforts at NBS; however, the timeframes for new measurement services were, in most cases, much to lengthy to provide relief for these immediate, critical requirements. The remaining 33% were either not addressed or so insufficiently addressed that no long term support to the nation could even be expected. Copies of this report were previously given to the Committee.

Another recent study by the IEEE committee formed to "promote national microwave standards" has reported a shortfall in calibration services in 75 areas critical to the microwave defense and communications industry alone. A report by the Armed Services has also indicated a significant shortfall in NBS' measurement services to meet the defense industry and service needs to develop, produce and sustain our weapons and combat systems that are essential to our nation's security.

In addition, the International Union of Radio Science (URSI) made a comparison of 30 national standards laboratories (including that of the USSR). This study, in the field of electrical, microwave and elecro-optical measurement services, clearly indicates that the NBS has lost is international preeminence in these fields. This loss has become a limiting factor in this nation's competitive position on high technology issues. It is clear that the actions taken over a decade and continued through this year are now being felt as severely as predicted by individuals in both our nation's industry and government agencies. Unlike many services of the Bureau, providing measurement references for the nation is not transferrable. The NBS is our sole source and is, therefore, either a long-term limiting or accelerating factor on national and international issues.

IMPACT OF THE PROBLEM

The measurement and standards role of the NBS is critical to all sectors of our economy and to all levels within those sectors - from research, to development, to production, to point of sale and beyond. Science, engineering, manufacturing, commerce and trade, as well as national security, all depend upon measurements - measurements which are consistent and which are valid because of the standardizing role of the NBS.

The rate at which industry can bring the fruits of research and development to useful, competitive products is highly dependent on valid measurements and standards. The utility of products that are competitively procured from multiple sources also depends upon this measurement and standards base. The significance of measurements on our overall economy was indicated in a recent report to be 3.5% of the Gross National Product - or in 1984, a total of $163B! For 20 measurement-intensive sectors, the contribution is even more dramatic. For those sectors, the value added by measurements is 13.5% or, in 1984,. $80B.

With a contribution this large - $80B for measurement intensive sectors and $163B overall - it is obvious that any action (or inaction) which serves to debilitate the basis of the system will have far reaching consequences. Erosion of the capabilities for measurement standards and services at the NBS have such consequences, although they are slow to surface. Some of the consequences of our past unwillingness to fully support the measurement and standards mission of the NBS are only now being felt. One area where this emergence has become visible has led to the formation of the special committee of the IEEE previously mentioned. This report indicates that key measurement requirements for the MILSTAR program are without measurement standards at the NBS. This has forced the DoD and industry to develop costly and time consuming workarounds. In these and other measurement areas, the effects of actions and inactions of the past are only now being perceived.

CAUSES OF THE PROBLEM

We realize that the National Bureau of Standards performs a variety of functions for the nation beginning with the missions outlined in the Organic Act of 1901 (and as amended from time to time) and extending to technical roles directed by Congress over the years. In our view, it would be a mistake to cite these additional roles (e.g., Brooks Act of 1965, Consumer Products Safety Act of 1973, Privacy Act of 1974, Energy Policy and Conservation Act of 1975, etc.) as the cause of our current problems. Rather, they are contributors to the current situation.

For example, the NBS is perceived by many - in government and the private sector - as the only nonspecific, laboratory oriented, scientific agency of the Federal Government. Thus, when scientific or technical studies or actions are required, the NBS is usually designated as the agency to carry it out - even though the study or action is not a standards one. In many respects, this makes sense. However, to the extent that these added studies or actions are expected to be carried out within existing budgets or manpower ceilings (a typical situation), all other functions assigned to the Bureau are impacted negatively.

In addition, over the recent past, the NBS has made certain organizational changes which we believe have served to defocus the fundamental and primary measurement and standards purpose of the Bureau. The creation of the National Measurement Laboratory and the National Engineering Laboratory have fragmented the measurement and standards thrust to the point where there is no emphasis or market based strategic planning for measurements or any commonality between the two laboratories on this vital purpose. Organizational defocusing has been exacerbated by the current lack of a measurement services user panel to review the continuing adequacy of NBS measurement services and the proliferation of roles that I previously referred to. When the Directorate of Measurement Services was eliminated, its high level panel was also eliminated.

This role as custodian of the nation's measurement standards and provider of these standards (through calibration services) to the myriad of users is not glamorous, nor does it attract the attention that - say - a major fire or building failure does. This role is - and probably rightly so - a transparent one, one that is taken for granted as we have come to expect that products perform as advertised. When they don't, we find that quality or some other measurement intensive factor has limited product performance and acceptance.

This transparency, though, implies to many that its priority relative to more visible or more glamorous roles is less. This implication leads to a disinterest of scientists and engineers to enter the field, to a management philosophy that tends to reduce emphasis in this sector and to "trade-off" its important functions for more publically and politically visible ones, and to the Administration and Congress to overlook the measurement focus.

SOLUTIONS AND RECOMMENDATIONS

We sincerely appreciate the opportunity you have provided us with to suggest our recommendations for the roles and missions of The National Bureau of Standards as it moves into its second century. You have the awesome responsibility of making the vital decisions which will shape the course of history - for the NBS, for all of us who depend upon it, and for the nation's industrial and commercial well being. We hope our contributions will be helpful in your deliberations.

What should the National Bureau of Standards be in 15 years (by the year 2000)? That depends to some extent on what you see it as now and what role you think government should play in these various missions. It is our judgement that the NBS is first the national standardizing laboratory of the United States. This mission requires that NBS scientists carry out research in the fundamental units of measurement, in many derived units, and in related areas. It requires that this research be translated into usefulservice by development of appropriate standards, publication of data, maintenance and custody of existing U.S. national standards, and the provision of the means to transfer these standards to industry, commerce, academia and government. It also requires that the NBS scientsists, engineers and managers involved in this activity participate in various forums aimed at identifying problems, setting priorities, sharing results of research, etc.

As a first approach, we believe that a part of the long term solution is the need to immediately refocus the various competing missions of the Bureau such that its principal objective again becomes that of being the custodian of national standards and of providing the means of transferring these standards to industry and commerce. And this means that at the very least all measurement and standards work at the Bureau must answer to one center or laboratory director.

We belive the time has come - perhaps has already passed - when a critical review of the performance of the NBS must be undertaken and a course of action defined to correct the conditions which have led to the perception that the NBS has fallen far short of meeting national requirements. Therefore, to help us attain the objective of redirecting the NBS to its principal mission and to continue the momentum provided by these hearings, Congress should support the execution of a Special Independent Commission. This Commission should examine all facets of the NBS, emphasizing the measurement and standards purpose. The goal of this examination should be to establish a direction for the future of the NBS including all missions and potential future missions. The composition of this commission should be strong in memberships from the measurement user's community - those who have the greatest knowledge of these needs. This has not always been evidenced in past committees participating in overviewing NBS activities.

We do not believe that the standardizing mission of the Bureau should be separated from its other important missions. But, if that is the only way the standardizing role can be returned to its rightful place as the principal reason for the existence of an NBS, then the other missions should be removed from the NBS and placed elsewhere. Another alternative to consider would make the Bureau itself a part of a larger "Department of Science or technology" wherein the standards mission is preeminent.

We also realize that part of what needs to be done may be politically distasteful. If all of the missions of the Bureau are of equal importance, then all must be funded to that equal position. We cannot afford to let the one basic important mission - measurement and standards - continue to be erroded because it is not glamorous or because it is perceived as the least visible. Therefore, one element of a solution requires improvement of the resource base (budget) by a significant amount. Development of this budget should be based on industry and other government agency assessment of measurement service requirements and priorities, and the publication of an annual National Measurement Services Plan. Management at all levels of the DOC and NBS should be committed to execution of this plan.

Another part of the solution requires an examination of the overall budget process itself which allows - perhaps ensures - that this condition will recur and get worse. Greater attention also should be paid to the use of universities and industrial or other government laboratories not only to develop new and improved measurement services, but also to expand the development of our most scarce resource - dedicated and competent metrology personnel. Of course, without an increased budget base and focus on the measurement service area, this attention seems unlikely. While this suggestion has long term payoff, immediate results can be obtained by utilization of existing international standards and measurement services as well as having NBS coordinate and validate Measurement Assurance programs, which have been developed by the NBS or others.

We believe that the role of the visiting Committee, its membership and selection process - indeed, its purpose - should be re-evaluated. The various evaluation panels of the NSF should be similarly reviewed. As in the management and organization suggestions and the funding proposal, it is necessary that all panels and evaluation committees re-new their interest in - and focus on - measurements and standards.

SUMMARY

At this point in the history of the U.S., nothing is more important in the area of technology development, manufacturing and international trade as the need to improve quality (in perception as well as in actuality), and the resulting improvement in productivity. Attainment of quality depends absolutely on our ability to measure - to assure that what is specified or required is achieved. And measurements depend upon a foundation of measurement equipment and standards which have a known relationship to an ultimate reference (in the U.S., the standards maintained by the NBS).

Many within the measurement community have believed for some time that there has been a continuing and serious atrophy of NBS' contribution to measurement science and services which would not be felt by this nation for some time. That time has passed! The situation is serious and, if allowed to continue, will result in a total breakdown in our National Measurement System and its essential support to our nation's economy and security. We believe immediate and major steps must be taken in the areas of mission focus, organization, planning, budgeting and the use of other national resources to begin the slow process of restoring the keystone to our national and international measurement systems.

Mr. WALGREN. Thank you, Mr. Nemeroff. I certainly appreciate that testimony and I think it is particularly useful to have for the record to refocus us on the basic mission of the Bureau and to underscore the fact that oftentimes the Bureau's assessment of the relative importance of missions or initiatives is divergent from that made by visiting committees, and I am sure many in the private sector as well.

In the back of Mr. Brown's testimony he had one of the charts of the 1987 initiatives, and there is quite a disparity between the importance NBS has put on microwave metrology and the importance the visiting committee has put on that area.

Mr. Brown, do you have any comments?

Mr. BROWN. Mr. Chairman, I'm not sure I have any questions. I am disturbed by this testimony because I think it indicates that the Congress has probably, in response to its high evaluation of the Bureau of Standards, tended to give it additional responsibilities, mandates, as we have done repeatedly over the last years, without recognizing that we may have diluted its primary function. And we didn't intend to do that. It's kind of happened. It's disturbing to have it called to our attention that something has gone wrong in the way in which we operate here.

I don't think its irreparable. I think this process that we're undergoing here may help us to remedy some of the problems that we have created, but I'm not sure just at this point what approach we may take to doing that. The Organic Act is quite emphatic in setting forth the priority of standards and measurements. What we have done is then to hang on that like a Christmas tree a number of other important functions but without providing the necessary resources and it's tended to dilute the emphasis given on the standards and measurements function which is critical to the goal that we're all seeking to achieve, which is improving the productivity and efficiency of the American industrial system and all of the related adjuncts to it—the scientific community and so on.

I wish there was some simple way we could remedy that. I'm not sure just how to go about it. But you've certainly given us a challenge to try and do that and I appreciate it very much. If you can tell us an easy way to restore the priority and restore the resources necessary to maintain that priority in the existing political climate, I'd be very happy to hear it. But I think it's going to take some work on our part in order to achieve that.

Mr. NEMEROFF. I think it will take work on the part of many people, Mr. Brown.

I would like to comment that this problem we have here is not unique. Other countries have faced it before. I've had a lot of experience and traveled the world out and visited national laboratories all over. Other countries have seen this problem, other national laboratories have seen this problem, and they've gotten around it.

In Canada, for instance, they've set up an independent corporation which is Government-owned, but yet is a profit-making company, where if somebody at the Canadian National Research Council, which is their equivalent of NBS, develops a product that may have commercial application—and be assured, the Bureau has come up with these things. Here in this country, if the Bureau, like any other Government agency, develops something, it becomes public domain.

In Canada, this is not so. In Canada, what they do, the patents are filed by a company called Canadian Patents and Development, Ltd. This is a Crown corporation. They do a research of the product. They actually do a market research to see is there any commercial application. And if there is, they then research and license a manufacturer to produce this product. And this manufacturer has to prove expertise in not only manufacturing or engineering or production, sales, marketing, but across the complete gamut.

When they select this manufacturer, they go to him and say "Do you want this?" And if they say yes, that manufacturer will pay a royalty back to the Government, which then refunds the Canadian National Research Council's future development in R&D program. In addition, some of that royalty goes right down to the inventing team.

Now, in return for that, the manufacturer sets up an R&D program to commercialize that product. You take a product that comes out of a scientific laboratory that is not ready for normal—as a commercial product; it has to be cleaned up; it's got to be redesigned—it could take up to 2 years. The manufacturer invests that.

But during that time he has the resources of that original inventing team to back him up. He can go to them and say, "Hey, guys, I need help", and that help is there. This does not happen in the United States. There is no incentive in this country for a manufacturer to pick up on a development that has been developed in a national laboratory or any U.S. Government laboratory, because it is public domain. That means if he does put the effort into it, and then somebody wants to buy it, somebody else can do it just as easily. The market may not be big enough or the incentive is not there. Other countries have done other things in similar manners.

Mr. Brown. This committee has long recognized the need for some sort of a Federal role in the process of improving productivity and technology in this country. We have tended to lay that responsibility upon agencies already doing a good job, in part because it's less controversial than establishing a new institutional structure such as the Canadian structure that you have referred to there. But we may have pressed our luck too far in this connection.

But the problem is represented by this. We have actually authorized in the Department of Commerce, separate from the Bureau, an Office of Productivity, Technology, and Innovation, OPTI. That office really is just a minuscule part or a minuscule approach to the overall problem. What we probably should have is at the minimum a bureau comparable to the Bureau of Standards which is engaged in that kind of activity, providing a service toward the improvement of productivity throughout the industrial structure.

And yet we find great difficulty, as we have seen, for example, through the lack of support for the Stevenson-Wydler Act, in getting that sort of thing accepted by the administration, and that leads us then to rely more upon something that is accepted, like the Bureau of Standards. Now, that can't continue, obviously, and you pointed out some of the reasons. It's diluting the fundamental role of the Bureau, and despite its stupendous efforts to maintain the high quality of its standards and measurements work, at least from your standpoint it hasn't kept up with the demand here. That's a very disturbing thing to find out about.

Mr. HAYES. If I might comment, Mr. Chairman and Congressman Brown, back in 1981–82 one of the panels that I was connected with that reviewed the work of the Bureau commented on the then 1980–82 long-range plan that I believe Deputy Secretary Brown referred to in his testimony yesterday. And this was probably the last panel that represented the National Research Council in reviewing an across-the-board look-see at what the Bureau was doing with measurement standards.

At that time the panel, in its report on the National Measurement Laboratory, commented that the panel was concerned about a disparity—and I quote—"between the limited resources of the Bureau and the type of mission statements presented to the panel." The panel also noted, with dismay, that the mission statements of the long-range plan appeared to lack any express recognition of the fundamental requirement of NBS to maintain the nation's standardizing and calibrating activities, as well as the Nation's basic standards.

I guess our reaction to that—and my reaction to that followed looking at the priority sheet you alluded to, in Mr. Brown's testimony, which ranked the microwave measurement area which is but the tip of the iceberg that we referred to here today as number 10 out of a priority of 11 new initiatives. That seems to not have altered significantly since 1981, if that's where we arrived at.

But we are concerned, I think, from our perspective, we aren't getting adequate attention focused on this matter, yet we understand that with a flat budget for the last ten years, there's only one way that you can get the funds to take on new initiatives, and that's to drain the funds from the existing reservoir. We believe the basic Christmas tree has become a fire hazard. It's lost all of its juices.

Mr. BROWN. I think this is accurate.

Now, what I would like, Mr. Chairman, if we could, is to have the staff look at that 1980 long-range plan and then compare it with the recent 1985 plan which Dr. Ambler indicated was available now, and see if we can learn anything by comparing these two.

Of course, the fact that the Bureau has more and more come to rely on financing from outside agencies, bears on this also because more and more of its efforts are being devoted to the service of other agencies and it's being funded to do that. These may not always be directly related to its central role.

Now, I'm not in any sense saying this isn't an extremely important function—I'm sure that it is—and it's certainly covered by the Organic Act. They are charged to provide services to other agencies of the Government, to State governments, to universities, and it may be that it has gone further in this direction than is healthy from the standpoint of a balanced program. I don't know that. I'm just raising that as a question that ought to be explored by us.

Mr. HAYES. One of my experiences, when I was with the Department of Navy, was that because we, 10 or 15 years ago, recognized an atrophy at the Bureau, dropping from 3,600 to 2,900, saw to it that additional Defense Department funds went into the Bureau.

Those funds were really being directed towards what I would look upon today as the core functions of NBS. Yet we realized, with great reluctance, we didn't want—we did not want to put the money there, but we felt we would not have even the standards we have today in the critical areas to the Department of Defense deployed systems had we not done that.

Before I left 2 or 3 years ago we made a final last plunge at pushing more funds through the Department of Defense from the three Services, in an attempt to have those funds focus and make perfectly clear Defense's continued support of NBS. But we've also made clear in informal relations with the Bureau that we really kind of resent having to put those funds up because they should be part of the core STRS inputs of the Bureau. But that lacking, and the fact that our satellites have got to work, and our defense systems have to work, we have seen to it to the best of our ability to put budgets in that would hopefully help support the OA inputs. But we also know we create an imbalance when we do that, and we create a lack of independence of that organization.

Mr. BROWN. It is true, I think, that the Defense Department is the largest contributor of any of the other agencies to the Bureau's operating funds.

Mr. Chairman, in view of the lateness of the hour, I will refrain from any additional comment on this.

Mr. WALGREN. Let me on behalf of the subcommittee then thank you for your presentation. We look forward to having that in the record and reviewing it carefully.

I would like to insert in the record, immediately after my opening statement, the opening statement of Congressman Boehlert. And, without objection, that will be the order.

That then will conclude these hearings. Thank you very much for your interest, folks.

Mr. HAYES. Thank you.

[Whereupon, at 6:08 p.m., the subcommittee was adjourned.]

APPENDIX

ADDITIONAL MATERIAL FOR THE RECORD

FORTUNE OCTOBER 28 1985

TECHNOLOGY

GM'S ROAD MAP TO AUTOMATED PLANTS

A proliferation of smart machines, unable to speak a common lingo, has been blocking the way to computerized factories. So General Motors, leading a buyers' uprising, has imposed a new standard that lets all the equipment work together.

■ *by Gene Bylinsky*

COMPLEX NEW technologies can be intimidating, particularly when they burst forth in a variety of incompatible makes and designs. Customers rarely step in to impose order, preferring to wait until the manufacturers collectively do so or, more commonly, until one competitor's triumphant product line sets the standards for all. Yet in a full-scale customers' revolt, giant corporations have moved to force compatibility on the panoply of electronic brains, robots, and machine tools that make up the factory of the future.

It helps that General Motors, with its enormous purchasing clout, has led the insurrection. By the late 1970s, GM's manufacturing executives saw that the proliferation of computer systems and "smart" production machines, each capable of communicating with only a limited number of other devices, was resulting in piecemeal automation—and a Babel of electronic tongues—on the factory floor. This barred the way to the automaker's dream of "computer-integrated manufacturing," in which every part of the production process is interconnected by a kind of central nervous system. Among the hoped-for blessings of such a system is coordination of the whole factory to a degree never before possible: overproduction or defects in any part or subassembly could be detected instantly, and the machines could be switched over within minutes to make different products.

The dream is alive and well, thanks to a standardized new communications system already in limited use at GM and at the plants of its allies in the users' revolt, including Deere, Boeing, and Eastman Kodak. Known as MAP—for manufacturing automation protocol—the network hooks up polyglot machines and lets them converse in electronic Esperanto. Early in November, MAP will make its public debut at the Autofact automated manufacturing show in Detroit's Cobo Hall. In a demonstration of the flexibility of computerized manufacturing, to be televised to Europe by satellite, different-colored versions of a plastic toy will be assembled by various manufacturers' computerized machines and robots. To select the color, a visitor will merely step up and punch a button.

Getting there hasn't been easy. GM initially ran into resistance from such big players in factory computerization as Digital Equipment and Hewlett-Packard, each with a stake in proprietary networks that would wed a customer to a limited range of products, mainly its own. These companies had reasons to fear a network that would accommodate any competitor's product. But now the old parochialism has been swallowed up in a surge of enthusiasm for a system that promises to benefit all by enlarging the total business.

"Corporate America and corporate Europe are behind MAP," says Alan Seely, general manager of Hewlett-Packard's network division. Though a late starter, corporate Japan is beginning to stir. Fanuc, GM's partner in the robot venture GMF, has announced it will use MAP in its own factories and will make the equipment it sells compatible with the new network. Recently representatives of 200 Japanese companies attended a GM briefing on MAP. There's general agreement that it will hasten the day of the push-button factory wherever it's adopted. An authority on the subject is Dennis E. Wisnosky, group vice president in charge of the industrial systems division at GCA Corp., a maker of automated equipment for producing semiconductor chips. Says Wisnosky: "MAP will bring about the realization of true computer-integrated manufacturing perhaps five to ten years sooner than it would otherwise have happened."

In essence, MAP is a highly sophisticated version of the local area networks, or LANs, that connect electronic equipment in offices and factories. But most LANs, such as Digital Equipment's Decnet or Allen-Bradley's Data Highway, are proprietary. Without a good deal of customizing, they hook up only a limited range of equipment—mainly the LAN maker's. MAP, which isn't patented and is free for all to copy, hooks up just about any make of equipment that would be needed in an automated factory, including present and future imported machines.

In physical appearance, MAP replaces isolated clumps of wiring, often improvised and unsightly, with a single, multichannel coaxial cable, about a half-inch in diameter, that can be buried in ceilings or floors. The cable, similar to those that deliver television programs to the home, can carry an impressive ten megabits of data a second—the equivalent of 1,250 typewritten pages. That's enough to let the cable perform extra duties, such as carrying voice and closed-circuit TV communications and running plant security systems. Hewlett-Packard, which is putting

MAP into two Roseville, California, factories that make printed circuit boards, will use it to send training film highlights right to workers' benches.

COMPUTERS, robots, and machine tools plug into the cable mechanically via an array of electronic black boxes and printed circuit boards. Incorporating elaborate software, these serve as "interfaces," converting each machine's signals to a common language. Proprietary networks, though likely to be superseded by MAP, can be equipped with translation devices and hooked up to the system too.

Engineers' eyes light up at one of MAP's biggest advantages. In most LANs, messages between individual electronic devices must vie for the use of a central channel. This can cause delays in transmission and loss of data when two or more machines try to "shout each other down" to get on the line. MAP will usher in the first widespread use of a "token," or baton-passing, system that guarantees each machine access to the line in rapid rotation. No data disappear in shouting matches and—crucially important in computerized factories where speed can prevent production bobbles—messages are passed quickly.

Merely by wiring all of a factory's machines together, MAP can save time and money. At Deere's sprawling, 96-acre combine and harvester plant in East Moline, Illinois, individual programs for numerically controlled machine tools, punched out on tapes in a central computer room, had to be hand-carried to the factory floor. If errors were discovered in the program, a tape had to be repunched, a procedure that could idle a machine for half a day or more. Now the instructions go out by wire, over a network compatible with MAP, from a so-called distributed numerical control system in the computer room. If mistakes crop up or a machine's program needs to be changed for any other reason, new instructions can be sent in minutes and production can quickly resume.

MAP's most powerful champion is Roger Smith, GM's chairman, who says that "without it the factory of the future would never be a reality." The concept actually percolated to the top from manufacturing executives and engineers who saw a half-dozen years ago that GM was creating a "communications monster" in its plants. Instead of a unified production system, the company was building islands of automation controlled by as many as a dozen separate networks. Each cluster of computerized machines—such as a stamping machine with a robot and inspection devices—operated on its own.

A later Eastman Kodak study showed that incompatibility was exacting a heavy price. Many of the isolated networks required custom-written software, whose preparation alone ate up a third of the installation time. Getting the clusters of computerized machines installed and hooked up—counting specially tailored wiring as well as software and training—accounted for half their cost. Once operating, the heterogeneous systems required an outsize force to maintain them. Even then, not all machines from the same manufacturer could communicate with each other. All too often, a scornfully named "sneaker network" of fleet-footed humans had to bridge the gap. Like their counterparts at Deere, they walked the data from one machine to another.

In 1980 GM set up a task force, with representatives from seven divisions, to develop MAP. Two years later, with top executives persuaded that MAP should be the highway to tomorrow's factories, GM announced it would use the network in all its plants and requested that equipment makers follow MAP's standards for interconnections.

In a world where standards are often dictated by a dominant supplier, such as IBM or AT&T, it was quite a switch for a leading customer to lay down the rules. Some suppliers bridled. Among those that resisted vigorously at first was Digital Equipment, whose widely used Decnet system has evolved over 15 years and has spurred the sale of the company's computers for use in the factory.

To bring the holdouts into line, GM coaxed and cajoled other network suppliers. An important persuader was Michael A. Kaminski, 52, the company's MAP project manager, whose bulldog tenacity makes up for his short stature. He is only five-four but says, "I've got big fists." Kaminski sometimes told little white lies. In approaching Allen-Bradley, a leader in factory automation, "I'd say, 'We got Gould,' " he recalls, "and then Allen-Bradley would say, 'Okay, if you've got Gould, we'll participate.' Then I'd go back to Gould and say, 'We've got Allen-Bradley and you guys better participate.' I'm not saying that we were unfair or that we were playing dirty pool. We could just see that MAP was the right way to go, and we were merely pointing out to the suppliers an opportunity they couldn't see."

When talk failed, Kaminski flexed GM's muscles. He suggested to companies that if their equipment were not compatible with MAP networks, it might be difficult to sell to GM in the future. Since then, in fact, compatibility with MAP has become part of the automaker's purchasing policy. When Kaminski discovered that some network suppliers were responding in a halfhearted fashion—planning to accommodate GM but to go on peddling their proprietary systems elsewhere—he decided that only concerted action among the customers would bring the suppliers into line.

Accordingly, with the help of some confederates at McDonnell Douglas, GM organized a MAP users' organization. To give MAP wide appeal, Kaminski recruited not only Ford and Chrysler but also a large contingent of companies outside the auto industry. The group's membership quickly grew. Some 60 attendees representing 45 companies showed up at the group's first meeting in St. Louis in 1984. A recent conclave, in Anaheim, California, drew more than 500 from 240 companies.

A late 1984 meeting at GM's Technical Center in Warren, Michigan, was an important turning point. Until then, GM's clout notwithstanding, the users had been somewhat cowed by the suppliers, and the atmosphere was frosty. Recalls an AT&T engineer who represented his company in its user's role: "I found Hewlett-Packard on one side of me, IBM on the other, and Digital Equipment behind me. At first you were almost afraid to speak out. But 15 to 20 minutes later, a curious thing happened—the whole room opened up. It was as if people threw away their company name tags."

In the changed atmosphere, peer pressure quickly brought once reluctant equipment makers into line. When a speaker from Digital Equipment rose to extoll Decnet after everyone else had spoken favorably about MAP, he was booed. Digital defends its long foot-dragging on MAP. Kevin O'Neill, in charge of marketing the company's manufacturing networks, says the company was concerned about the high costs of introducing a new system. His company also hung back from MAP, he says, because it didn't like the way GM kept changing the specifications until last year. Now Digital is a MAP supporter. At the latest users' meeting, in another harbinger of things to come, Gould announced that it was dropping its proprietary network, Modway, in favor of MAP.

Some 100 suppliers of equipment and components, ranging from tiny Silicon Valley start-up companies to IBM, have endorsed MAP. Big Blue, with a relatively smaller stake in factory automation than some of its rivals and no proprietary network, never put up much resistance. The business of supplying cable, mechanical connectors, circuit boards, and black boxes should grow to $1 billion a year by 1988, according to an estimate by Motorola. Among the cable suppliers are Belden, a division of Cooper Industries, and Times Fiber Communications Inc. Because of its greater complexity, MAP is costlier than proprietary networks. But the gain in compatibility more than makes up for the added expense, and costs are bound to come down as semiconductor manufacturers enter the game, reducing the cost of components by executing them on specialized silicon chips.

SPEARHEADING this kind of electronic shrinkage is Industrial Networking Inc. (INI) of Santa Clara, California, the only company making nothing but components for MAP networks. Founded last year and controlled by Ungermann-Bass, which supplies chips and other parts for Xerox's Ethernet local area network, INI also got a $6-million infusion from General Electric, which holds a 40% stake. INI has beaten bigger rivals to the punch with the first set of complete MAP products, including two chips that shunt signals as well as software and printed circuit boards. Joseph P. Schoendorf, INI's president, sees sales reaching $100 million in five years. INI will have plenty of company when the big semiconductor houses start spitting out MAP chips by the million. Motorola and Intel already offer a few types, and more will be out soon.

For all the enthusiasm, MAP is still in the development and shakedown phase. The elaborate standards and specifications are subject to slightly varying interpretations by different engineers. In a small bump on the road to MAP, three different companies' modems were recently found unable to converse with each other. As an interim solution, suppliers such as Allen-Bradley have had to equip their process controllers with three printed circuit boards instead of one, to ensure compatibility. Such problems, however, appear surmountable. To make sure "smart" machines can speak MAP's language, the Industrial Technology Institute in Ann Arbor, Michigan, an independent research organization, has taken on the job of testing them. Its imprimatur will be somewhat analogous to the Underwriters Laboratories label on electrical equipment.

GM, though more heavily committed to MAP than any other company, is proceeding cautiously in installing the network. The automaker's Electronic Data Systems subsidiary, acquired in 1984, will purchase all the equipment and supervise the installation work. In some GM plants MAP has met a lukewarm reception, and even some resistance, because many plant managers abhor change. So a vast educational and training effort lies ahead.

GM already has pilot projects, incorporating limited MAP networks, at several plants. More extensive networks will go into operation next year, including one at a Saginaw, Michigan, plant that will make axles for cars with front-wheel drive. The plant will have 50 "cells," or clusters of computer-run machines, each incorporating such equipment as robots and numerically controlled machine tools. With MAP, the plant's managers will be able to order a switchover to producing a different kind of axle—with all the tooling changes—simply by pressing buttons. A changeover now takes three days; MAP will cut it to ten minutes.

At Saginaw, and elsewhere in GM, machines that automatically inspect newly made parts for defects will be able to send a timely warning via MAP to the machines making them. That will avoid a pileup of defective parts, which is a common headache in automated plants. GM plans to make MAP virtually universal in its plants by 1990.

BY EMBRACING MAP early, GM and other U.S. manufacturers hope to leapfrog Japan, until now the pacesetter in factory automation. Wisnosky of GCA Corp. thinks American companies have a three- to five-year head start over the Japanese with MAP. Japan and other countries, he allows, will try to catch up. "If our machine controllers and robots are the first to be compatible with MAP," says Wisnosky, "the rest of the world will have to follow us."

If MAP became universal, the work of the computerized factory could be efficiently parceled out among countries as never before. The MAP network can be extended beyond a single plant by long-distance telephone lines and communications satellites. Suppose, says Wisnosky, the Italians are deemed best for designing a new car, the Japanese seem the best bet for producing the power train, and a plant close to major U.S. markets makes the most sense as an assembly point. Design and tooling could be orchestrated across frontiers—and communicated instantaneously—through MAP. That would not only put the new car in showrooms sooner, but give a new dimension to the global division of labor. ■

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GM to Unveil Network Aimed at Linking Computer Systems in Automated Factory

By Doron P. Levin
Staff Reporter of The Wall Street Journal

WARREN, Mich. – General Motors Corp. will unveil next month its model of the automated factory of the future, featuring a system it hopes will lay down ground rules for the computer industry that will supply the sophisticated equipment needed.

The demonstration, in which work stations from 25 different computer vendors, will "talk" to each other, caps a five-year drive by the big auto maker to speed the day when manufacturers can plug computers, bought from various makers, into systems in place on the factory floor, allowing robots, engineers, managers and designers to exchange data.

GM and factory-automation experts believe the model proves that a standard "protocol," controlling such things as the speed at which data is exchanged between different makers' computers, is feasible. The system–called Manufacturing Automation Protocol (MAP)–will link robots and other high-technology units via a network over coaxial wire, similar to that for cable TV. They say this computer-driven network eventually could extend to suppliers and perhaps even to retail outlets.

Some of the names of companies that will demonstrate equipment in November suggest that GM has managed to line up big players. Among them are American Telephone & Telegraph Co., Digital Equipment Corp., International Business Machines Corp., Hewlett-Packard Co. and Rockwell International Corp.'s Allen-Bradley unit.

With the show, GM hopes to take a big step toward its goal of creating an industry standard, one that will help computer vendors to make "plug-in" equipment. Today, various high-tech applications such as industrial robots operate as islands, without the ability to communicate with the rest of the manufacturing process. Until now, each vendor developed proprietary protocols that worked only with its equipment.

To communicate, under current technology, such islands must be fitted with expensive translating computers and additional wiring; in some cases, data now must be transferred manually from one computer terminal to another.

MAP has its skeptics. While Ford Motor Co. supports the concept, the No. 2 auto maker believes some time will pass before it catches on. "A cost-effective integrated plant system is still about 10 years away," says Max Jurosek, Ford's general manager of power train operations. "There are a lot of good demonstrations but they entail about 20% to 30% of the effort it will require to make such a system cost effective." GM officials say they don't have any basis yet to determine when the high-technology factory will be cost effective.

Early next year, GM itself plans to open a new steering gear plant in Saginaw, Mich., that it believes will be the first to use equipment guided by computers that will share a common protocol. At about the same time, GM says it will install similar systems into its most advanced auto assembly plant, in Hamtramck, Mich., and at a truck plant in Pontiac, Mich. Elements of a MAP system already are being used or developed, on a limited basis, at plants owned by Ford Motor Co., Deere & Co. and IBM.

The experts credit GM with being the force behind the effort to develop an industry-wide computer protocol standard. With its multibillion-dollar buying power, the auto maker is the largest and most influential customer in the world for automation equipment. After a decade of initial attempts to automate isolated industrial processes, GM and other manufacturers came to realize by 1980 that cost-effective automation required larger, integrated systems.

David Morgan, of the Industrial Technology Institute of Ann Arbor, Mich., says: "In the history of computers and communication, the customers always have bought and accepted products. This is one of the few times the users have defined what they need."

Some factory-automation vendors had been skeptical that GM's initiative would bear fruit. Thus, many vendors were lukewarm about developing products that would operate with a new protocol. Others were reluctant to spend capital on compatible equipment unless it became clear everyone would accept it.

Only after GM began insisting in the early 1980s that it would buy only MAP-compatible equipment for its plants did the vendors commit to the system.

The project has made converts of some vendors who had invested heavily in early automation equipment that will be made obsolete by MAP. Gould Inc., before joining the GM project, had spent upward of $5 million to develop its own networking protocol. "When we took our first plane ride out to GM in 1981 it was a tough sell," says Bruce MacAloney, Gould's manager of MAP. "We now think MAP is going to be an industry standard."

MAP's developers promise that the creation of an industry-wide standard assures that such a thing won't happen again. "We're committed to the concept of graceful migration," says Paul Borawski of the Society of Manufacturing Engineers. "That means that plants won't have to scrap anything to accommodate future refinements in MAP."

The GM model will be on display Nov. 4 at the society's factory automation show in Detroit. In addition to MAP, the GM model will demonstrate a Technical and Office Protocol (TOP), which is being proposed as a standard for office computer systems used in coordination with manufacturing plants.

Mr. Borawski says: "Everything that anyone needs to know about whether MAP will work will be on display." Says Pat Reily, AT&T manager for automation planning: "We sure think a protocol is here and is for real. The thing has reached critical mass."

"Anyone who is serious about factory automation will have to speak MAP," adds Mr. Morgan of the Industrial Technology Institute.

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THE INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS, INC.

November 1985

Protocol chips unveiled at MAP users' group meeting

Anaheim, Calif.—General Motors has put its considerable clout behind its Manufacturing Automation Protocol (MAP) and it's paying off. At least that was the strong indication here at last month's meeting of the MAP users' group. The meeting was sparked by a rash of new MAP product introductions, new MAP commitment announcements, and encouraging progress reports from those companies that had previously announced their support of MAP.

General Motors has said that it will no longer purchase any factory automation equipment that does not conform to MAP. MAP, which defines a network communications structure for multivendor factory automation systems, is based on the Open Systems Interconnection reference model developed by the International Standards Organization (ISO) and the Consultative Committee International Telephone and Telegraph (CCITT). MAP uses both existing and emerging international communications standards to provide the basis for communications among such factory-floor devices as robots, programmable controllers, machine tools, and computers.

New MAP products offered

Among the new products introduced was Industrial Networking Inc.'s MAP/One product line. Based on IEEE and ISO standards, this complete set of hardware and software products that implements all seven layers of MAP, is a milestone in MAP implementation progress. The product line is said by the Santa Clara, Calif., firm to include the first circuit chips that work with the MAP protocol.

The product line, based on the Intel 80186 processor with dual custom gate arrays for handling the token passing protocol, consists of the following six products:

- MM-400, a MAP interface for multibus systems, provides the link between an IEEE-802.4 standard broadband token-bus local area network (LAN) and a system based on the Multibus. MM-400 includes a 10 megabits per second modem maintain the MAP/One token-bus LAN. It provides the tools needed to get the network started and keep it running efficiently and responsively.
- MHR-40, a head-end remodulator, is a rack-mountable system level product used as the central retransmission facility for a 10 Mb/s MAP LAN. It provides frequency translation between received and transmitted signals, decodes and reencodes data, and provides the master clock for all modems in the network.

General Electric Co., in a joint venture with Ungermann-Bass Inc., formed INI in September 1984, and INI was GE's partner in developing GEnet Factory LAN, also announced at the MAP users' group meeting. It is based on the INI products previously described.

GE will use GEnet Factory LAN to integrate its automation products, including the series Six, Three, One, and One Junior family of programmable controllers; the Workmaster family of industrial computers; and the Mark Century 2000 CNC numerical control.

The GEnet Factory LAN will consist of a bus interface unit (BIU), head-end remodulator, the Workmaster network management console, and software packages for attaching various classes of devices.

The BIU will be based on INI's token-bus interface adapter. It will be a two-port device, rack- or panel-mounted, and designed to meet industrial environmental specifications. The two ports are independently configurable for asynchronous or synchronous operation with data rates to 56 kilobits per second.

The BIU is tailored by loading device-specific software to provide the required interface for various automation products. For example, any device supporting GE's CCM protocol can access the GEnet factory LAN with translation to MAP by way of a simple software download to the BIU. So all of the GE programmable controllers as well as the Workmaster family can communicate with any MAP-compliant device on the network.

To attach the Mark Century 2000 CNC to the GEnet factory LAN, the standard BIU is loaded with the high-level data link control interface software. The 2000 uses the FMS/MAP option, a powerful new communications processor that supports the higher layer MAP protocols.

The network management console provides for overall system configuration, management, network diagnostics, and performance monitoring. It is based on the Workmaster family of industrial computers and includes the GEnet PC-BIU and network management software. The PC-BIU is a card set that plugs into the console's backplane and connects it to the network. The NMC function also can operate on a standard IBM PC/XT.

The head-end remodulator receives signals from individual stations, raises the frequency of the signals by 192.25 megahertz, and retransmits a regenerated signal. This provides for operation on the broadband cable in one of three available channel allocations.

In another announcement, Gould Inc.'s Industrial Automation division in Andover, Mass., reported that it will no longer market Modway, its own factory communications system, but has created a Modway replacement gateway program to support those Modway users who want to install and use a MAP network.

MAP commitments, progress

Among the new companies announcing commitments to MAP in Anaheim were: McDonnell Douglas, 3M, Lockheed Corp., and Proctor & Gamble.

MAP pilot programs were outlined by: E.I. Dupont de Nemours, IBM, Public Service of New Mexico, and the National Bureau of Standards. —*Ronald K. Jurgen*